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Taskiran-Cyr

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(54) **SYSTEM AND METHOD FOR UPGRADING A MULTIPROCESSOR SET-TOP BOX DEVICE WITH A MONOLITHIC FIRMWARE IMAGE**

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This patent is subject to a terminal disclaimer.

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Related U.S. Application Data

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(60) Provisional application No. 61/006,055, filed on Dec. 17, 2007, provisional application No. 61/006,054, filed on Dec. 17, 2007.

(51) **Int. Cl.**

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H04N 21/443	(2011.01)
H04N 21/236	(2011.01)
H04N 21/258	(2011.01)
H04N 21/426	(2011.01)
H04N 21/61	(2011.01)
H04N 21/81	(2011.01)

(52) **U.S. Cl.**

CPC ***H04N 21/443*** (2013.01); ***H04N 7/17318*** (2013.01); ***H04N 21/23617*** (2013.01); ***H04N 21/25816*** (2013.01); ***H04N 21/42676*** (2013.01); ***H04N 21/6168*** (2013.01); ***H04N 21/8166*** (2013.01)

(58) **Field of Classification Search**

CPC combination set(s) only.

See application file for complete search history.

(56) **References Cited**

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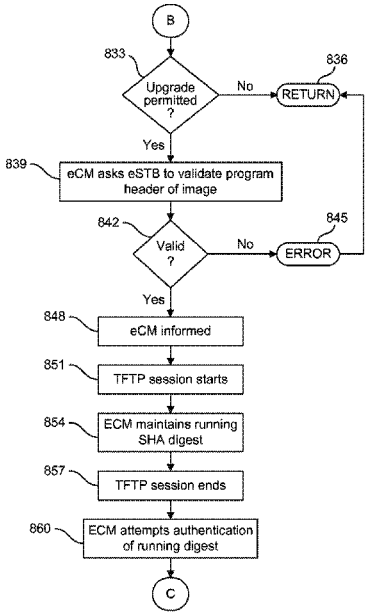
(57) **ABSTRACT**

A system and method for downloading a code image at a set-top gateway host that includes an embedded set-top box and an embedded cable modem. The embedded set-top box and the embedded cable modem interact so that each leverages the resources of the other, thereby minimizing the functionality that must be built into each.

20 Claims, 22 Drawing Sheets



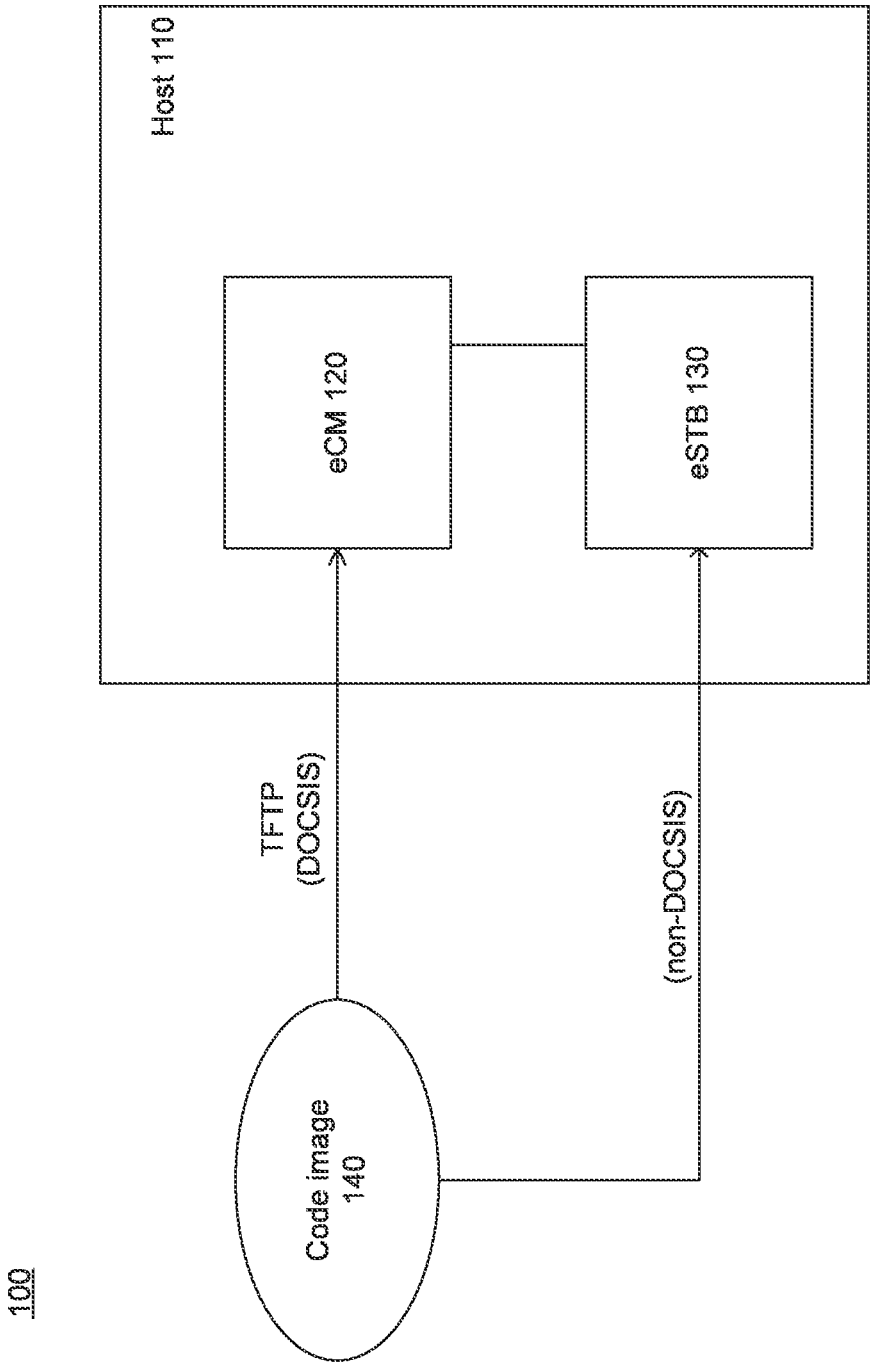

100
Host 110
eCM 120
eSTB 130
TFTP
(DOCSIS)
(non-DOCSIS)
Code image
140

FIG. 1

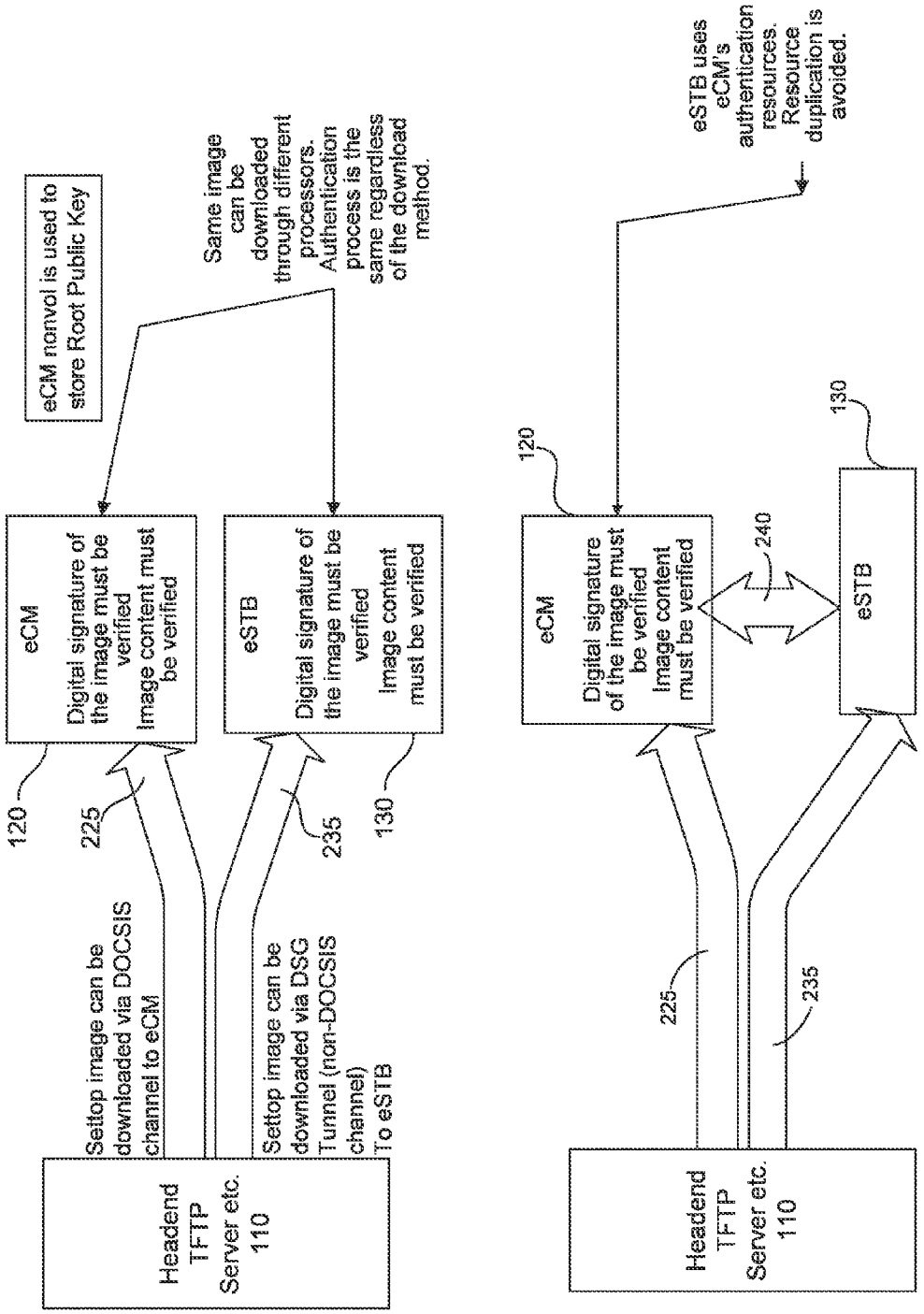

eCM nonvol is used to store Root Public Key
Same image can be downloaded through different processors. Authentication process is the same regardless of the download method.
eCM
Digital signature of the image must be verified
Image content must be verified
eSTB
Digital signature of the image must be verified
Image content must be verified
120
225
235
130
Settop image can be downloaded via DOCSIS channel to eCM
Settop image can be downloaded via DSG Tunnel (non-DOCSIS channel) To eSTB
Headend TFTP Server etc. 110
eSTB uses eCM's authentication resources. Resource duplication is avoided.
120
130
240
eCM
Digital signature of the image must be verified
Image content must be verified
eSTB
225
235
Headend TFTP Server etc. 110

FIG. 2

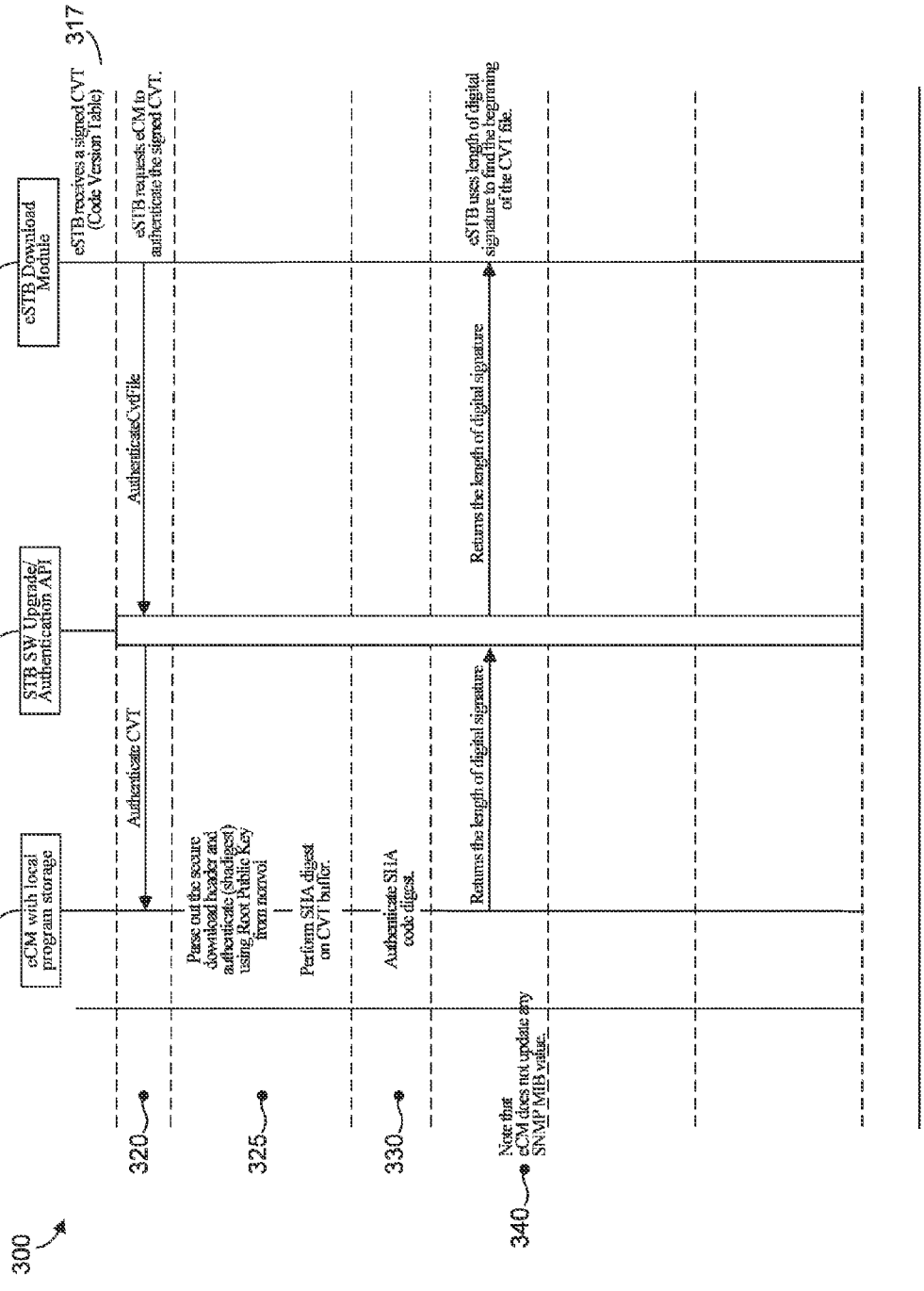

300
120
eCM with local program storage
315
STB SW Upgrade/ Authentication API
305
eSTB Download Module
317
eSTB receives a signed CVT (Code Version Table)
eSTB requests eCM to authenticate the signed CVT.
AuthenticateCvtFile
Authenticate CVT
Returns the length of digital signature
eSTB uses length of digital signature to find the beginning of the CVT file.
320
Parse out the secure download header and authenticate (Shadigest) using Root Public Key from nonvol
325
Perform SHA digest on CVT buffer.
330
Authenticate SHA code digest.
Returns the length of digital signature
340
Note that eCM does not update any SNMP MIB value.

FIG. 3

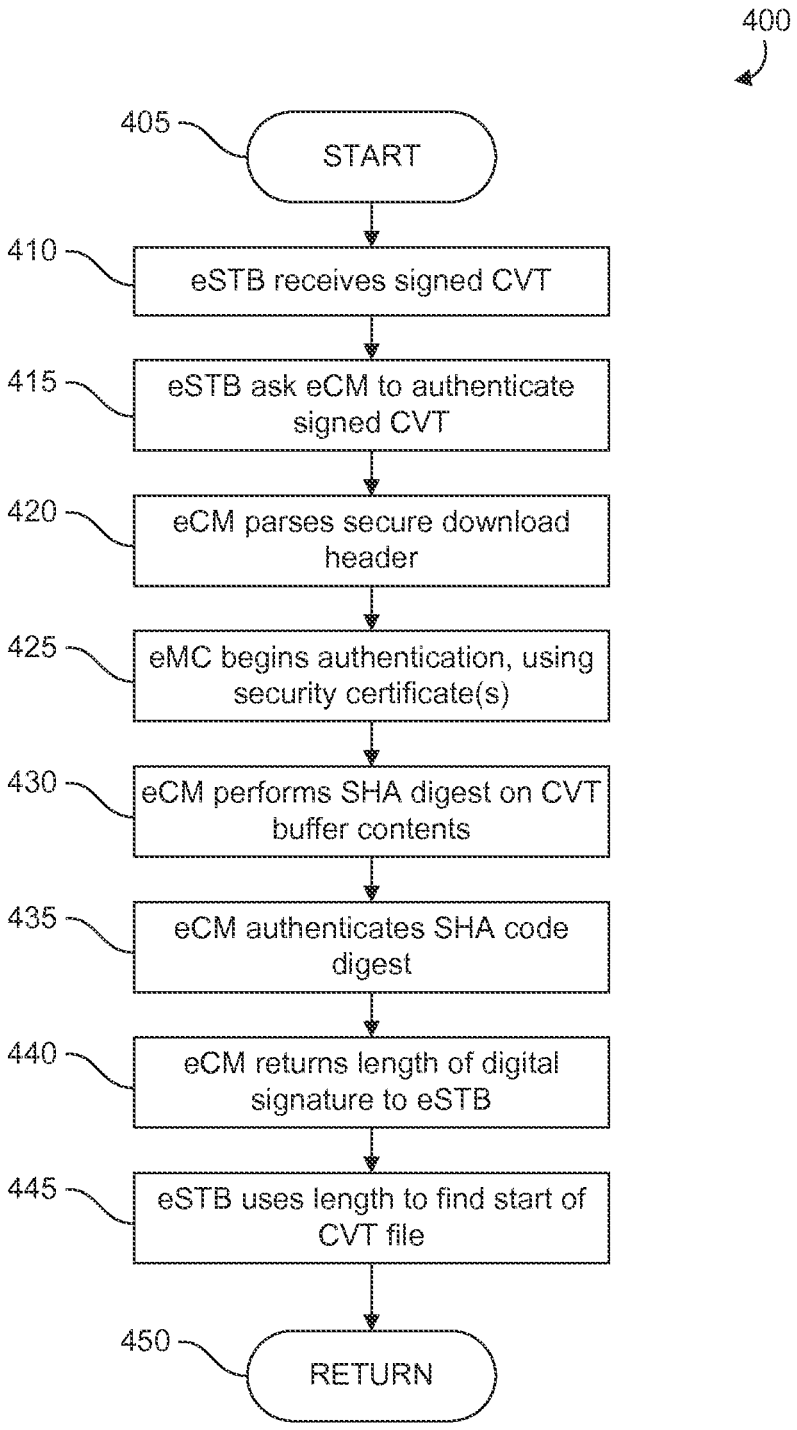

400
405
START
410
eSTB receives signed CVT
415
eSTB ask eCM to authenticate signed CVT
420
eCM parses secure download header
425
eMC begins authentication, using security certificate(s)
430
eCM performs SHA digest on CVT buffer contents
435
eCM authenticates SHA code digest
440
eCM returns length of digital signature to eSTB
445
eSTB uses length to find start of CVT file
450
RETURN

FIG. 4

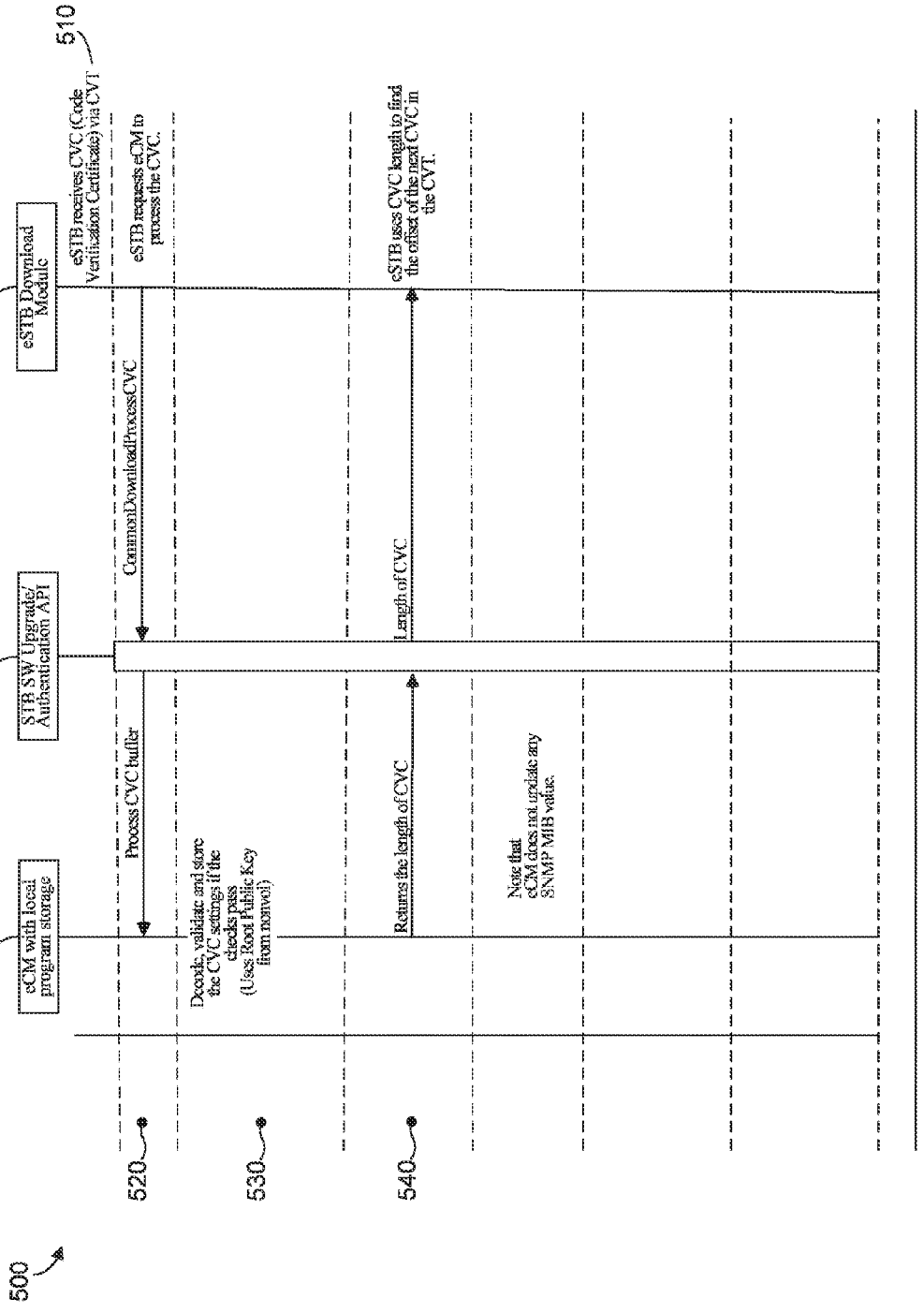

500
120
eCM with local program storage
315
STB SW Upgrade/ Authentication API
305
eSTB Download Module
510
eSTB receives CVC (Code Verification Certificate) via CVT
eSTB requests eCM to process the CVC.
CommonDownloadProcessCVC
Process CVC buffer
Decode, validate and store the CVC settings if the checks pass (Uses Root Public Key from nonvol)
Returns the length of CVC
Length of CVC
eSTB uses CVC length to find the offset of the next CVC in the CVT.
Note that eCM does not update any SNMP MIB value.
520
530
540

FIG. 5

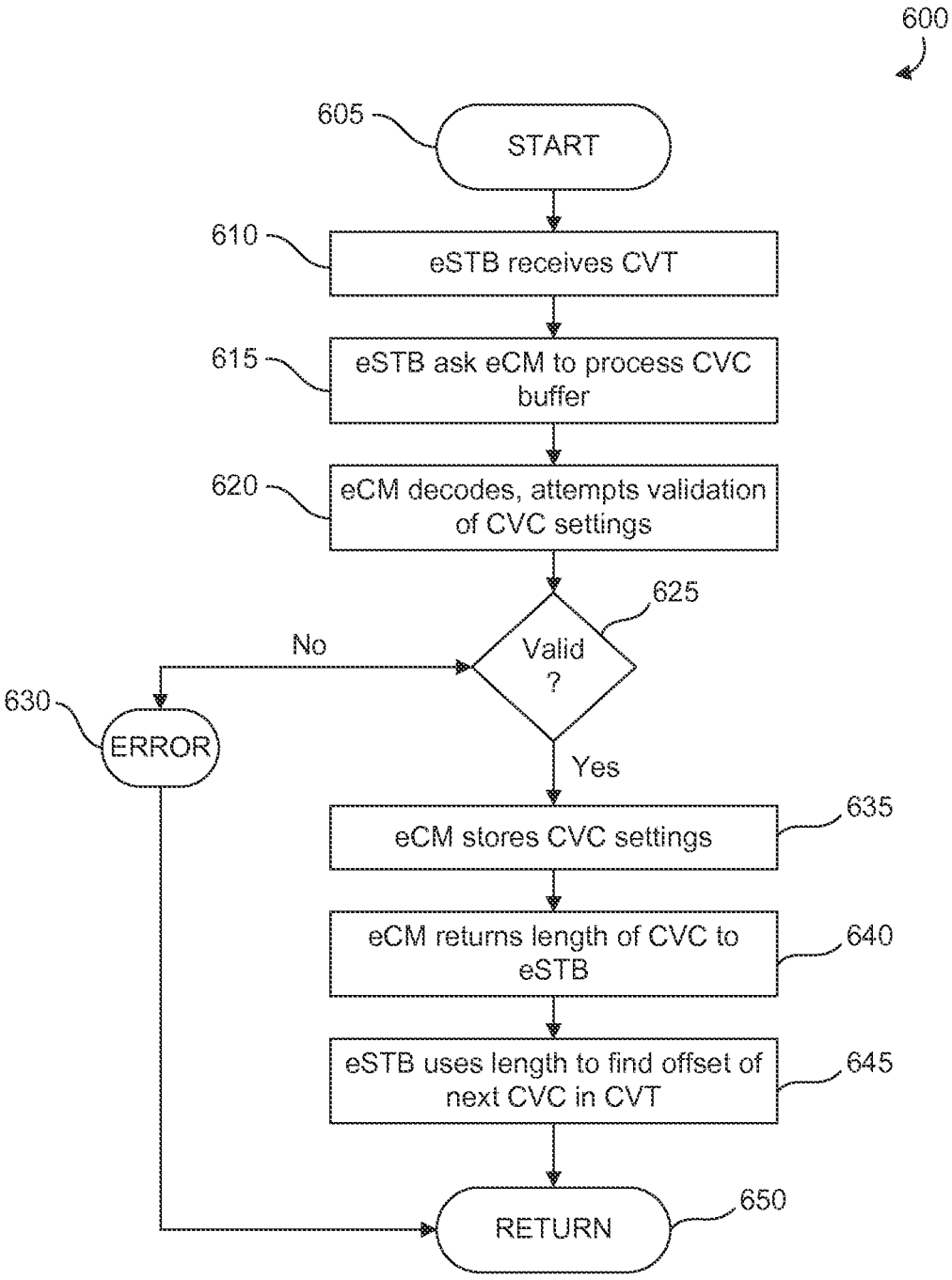

600
605
START
610
eSTB receives CVT
615
eSTB ask eCM to process CVC buffer
620
eCM decodes, attempts validation of CVC settings
625
Valid ?
No
630
ERROR
Yes
635
eCM stores CVC settings
640
eCM returns length of CVC to eSTB
645
eSTB uses length to find offset of next CVC in CVT
650
RETURN

FIG. 6

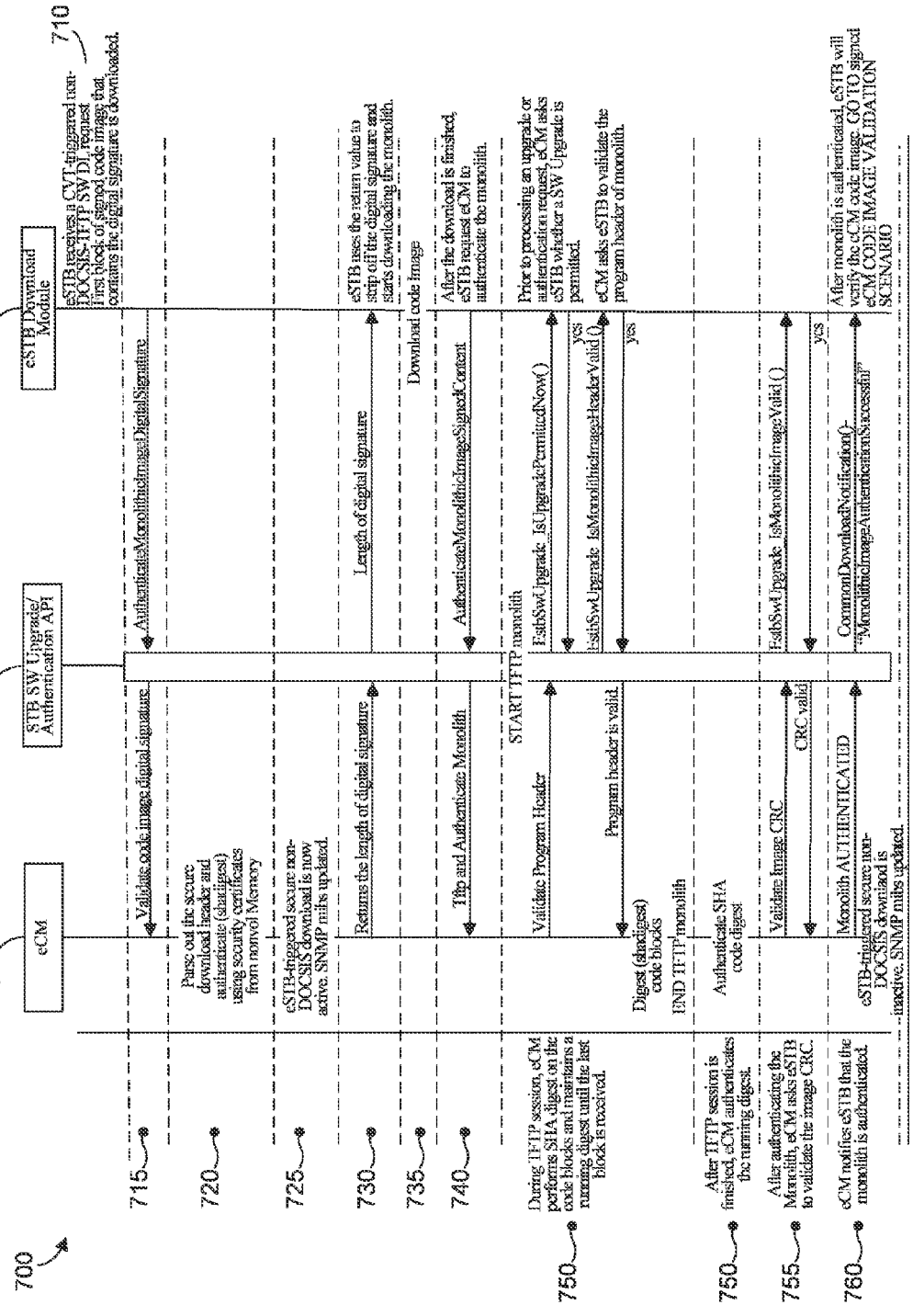

700
120
eCM
315
STB SW Upgrade/ Authentication API
305
eSTB Download Module
710
eSTB receives a CVT-triggered non-DOCSIS-TFTP SW DI request. First block of signed code image that contains the digital signature is downloaded.
715
Validate code image digital signature
AuthenticateMonolithicImageDigitalSignature
720
Parse out the secure download header and authenticate (sha1digest) using security certificates from nonvol Memory
725
eSTB-triggered secure non-DOCSIS download is now active. SNMP mibs updated.
730
Returns the length of digital signature
Length of digital signature
eSTB uses the return value to strip off the digital signature and starts downloading the monolith.
735
Download code image
740
Tftp and Authenticate Monolith
AuthenticateMonolithicImageSignedContent
After the download is finished, eSTB requests eCM to authenticate the monolith.
START TFTP monolith
750
During TFTP session, eCM performs SHA digest on the code blocks and maintains a running digest until the last block is received.
Validate Program Header
IsEstbSwUpgrade IsUpgradePermittedNow()
Prior to processing an upgrade or authentication request, eCM asks eSTB whether a SW Upgrade is permitted.
yes
IsEstbSwUpgrade IsMonolithicImageHeaderValid ()
eCM asks eSTB to validate the program header of monolith.
yes
Program header is valid.
Digest (sha1digest) code blocks
END TFTP monolith
750
After TFTP session is finished, eCM authenticates the running digest.
Authenticate SHA code digest
755
After authenticating the Monolith, eCM asks eSTB to validate the image CRC.
Validate Image CRC
IsEstbSwUpgrade IsMonolithicImageValid ()
CRC valid
yes
760
eCM notifies eSTB that the monolith is authenticated.
Monolith AUTHENTICATED
CommonDownloadNotification()- "MonolithicImageAuthenticationSuccessful"
After monolith is authenticated, eSTB will verify the eCM code image. GO TO signed eCM CODE IMAGE VALIDATION SCENARIO
eSTB-triggered secure non-DOCSIS download is inactive. SNMP mibs updated.

FIG. 7

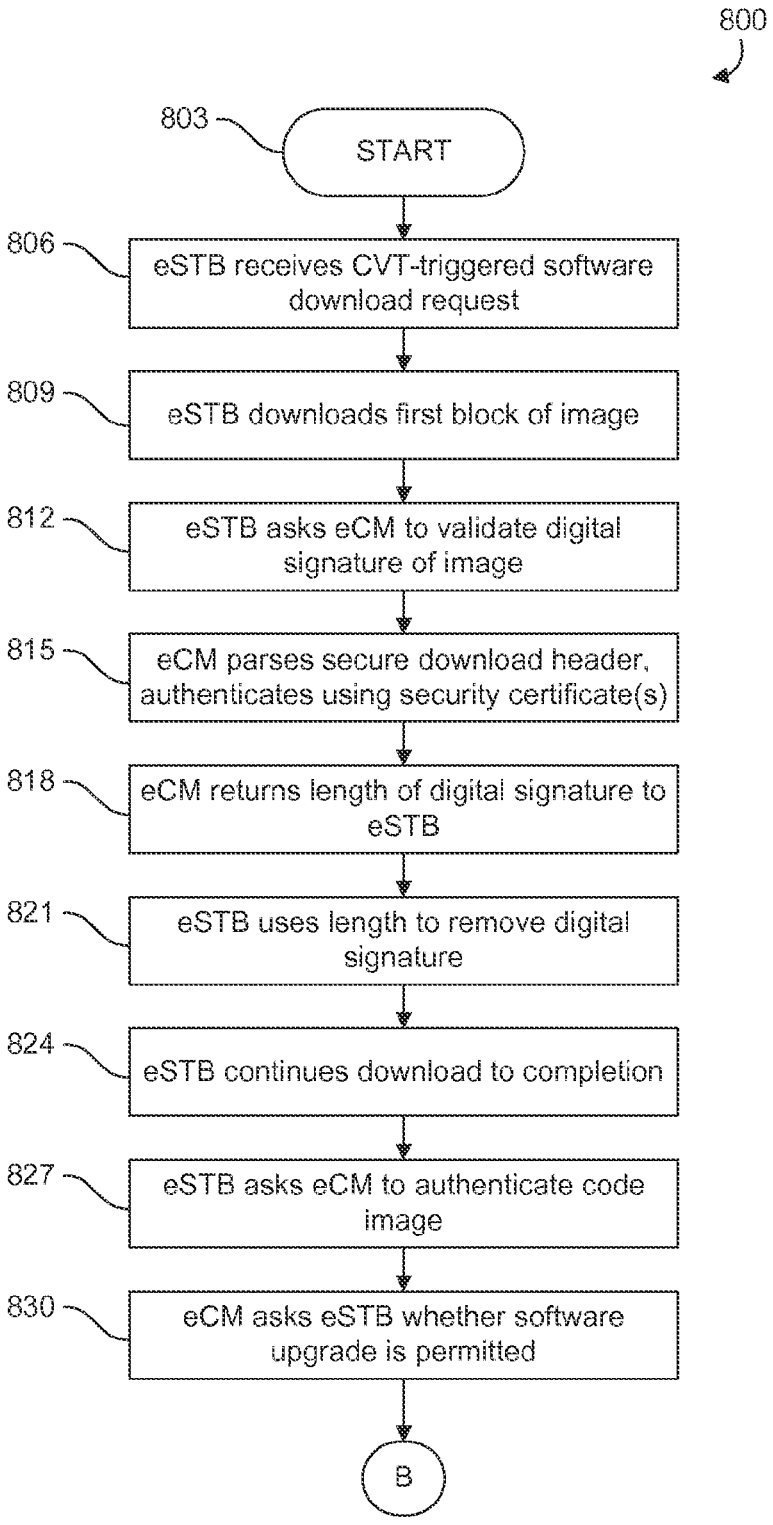

800
803
START
806
eSTB receives CVT-triggered software download request
809
eSTB downloads first block of image
812
eSTB asks eCM to validate digital signature of image
815
eCM parses secure download header, authenticates using security certificate(s)
818
eCM returns length of digital signature to eSTB
821
eSTB uses length to remove digital signature
824
eSTB continues download to completion
827
eSTB asks eCM to authenticate code image
830
eCM asks eSTB whether software upgrade is permitted
B

FIG. 8A

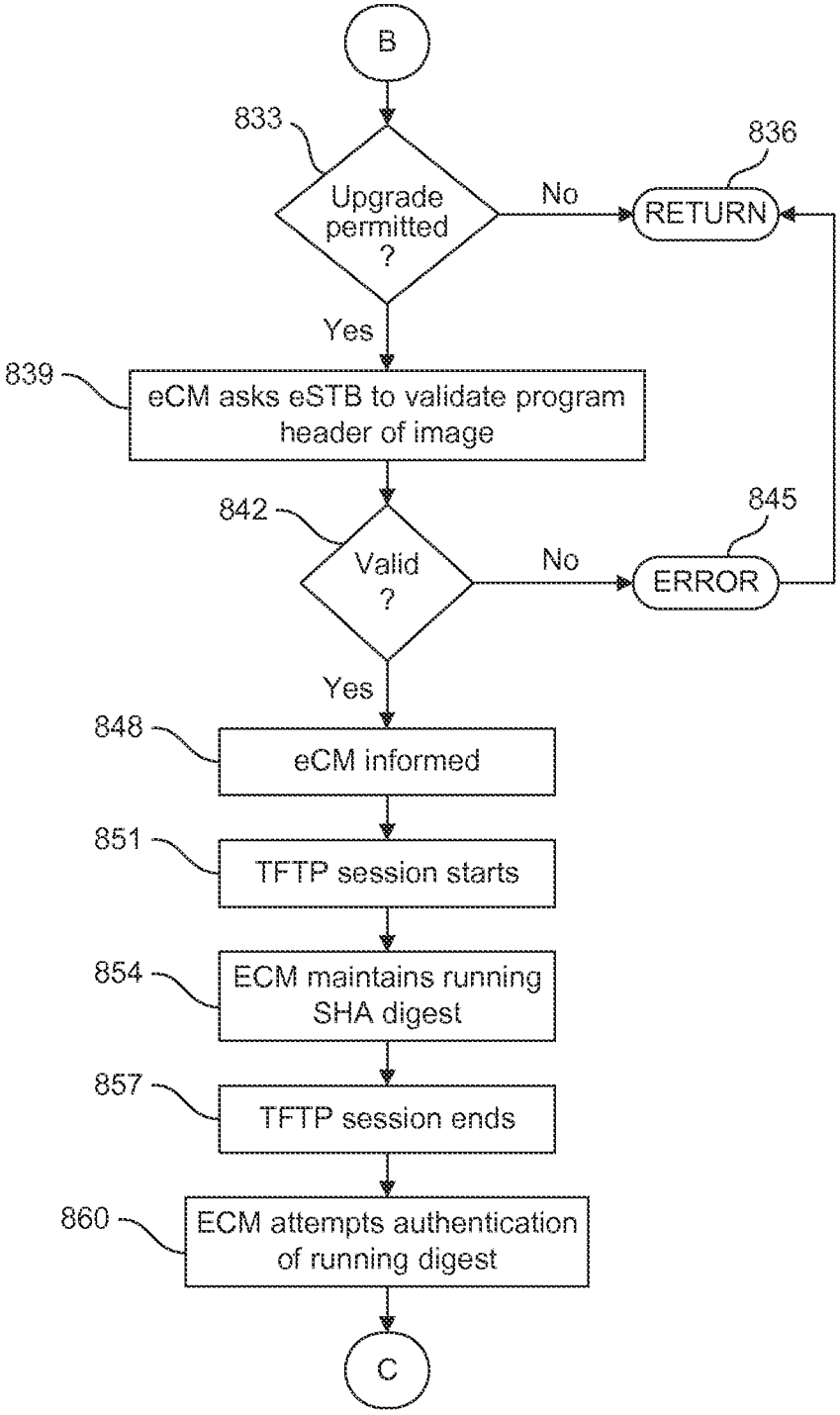

B
833
Upgrade permitted ?
No
836
RETURN
Yes
839
eCM asks eSTB to validate program header of image
842
Valid ?
No
845
ERROR
Yes
848
eCM informed
851
TFTP session starts
854
ECM maintains running SHA digest
857
TFTP session ends
860
ECM attempts authentication of running digest
C

FIG. 8B

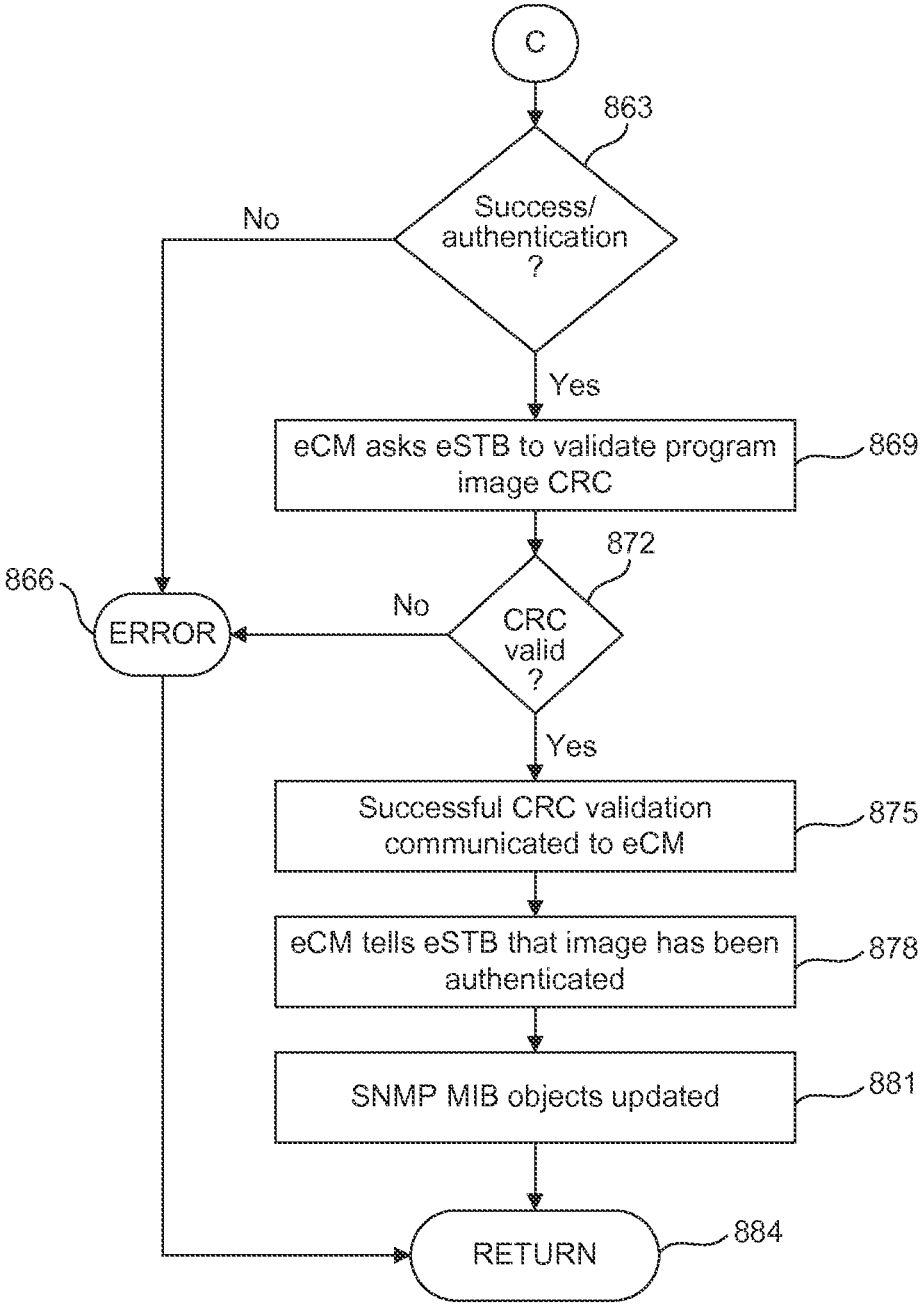

C
863
Success/ authentication ?
No
Yes
eCM asks eSTB to validate program image CRC
869
872
866
ERROR
No
CRC valid ?
Yes
Successful CRC validation communicated to eCM
875
eCM tells eSTB that image has been authenticated
878
SNMP MIB objects updated
881
RETURN
884

FIG. 8C

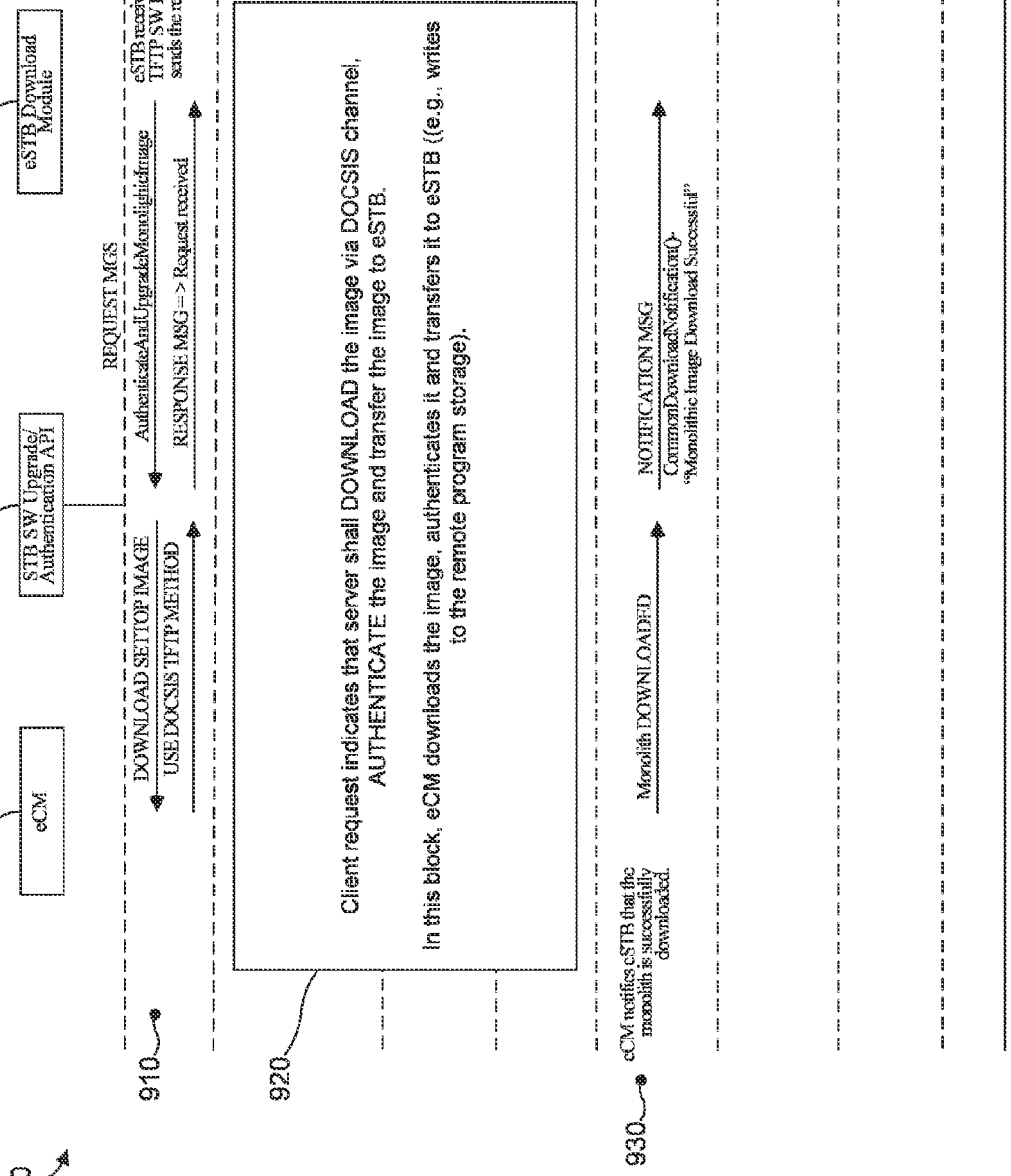

900
120
eCM
315
STB SW Upgrade/ Authentication API
305
eSTB Download Module
910
920
930
DOWNLOAD SETTOP IMAGE
USE DOCSIS TFTP METHOD
REQUEST MGS
AuthenticateAndUpgradeMonolithicImage
RESPONSE MSG = > Request received
eSTB receives a DOCSIS-TFTP SW DL request and sends the request to eCM.
Client request indicates that server shall DOWNLOAD the image via DOCSIS channel, AUTHENTICATE the image and transfer the image to eSTB.
In this block, eCM downloads the image, authenticates it and transfers it to eSTB ((e.g., writes to the remote program storage).
Monolith DOWNLOADED
NOTIFICATION MSG
CommonDownloadNotification()-
"Monolithic Image Download Successful"
eCM notifies eSTB that the monolith is successfully downloaded.

FIG. 9

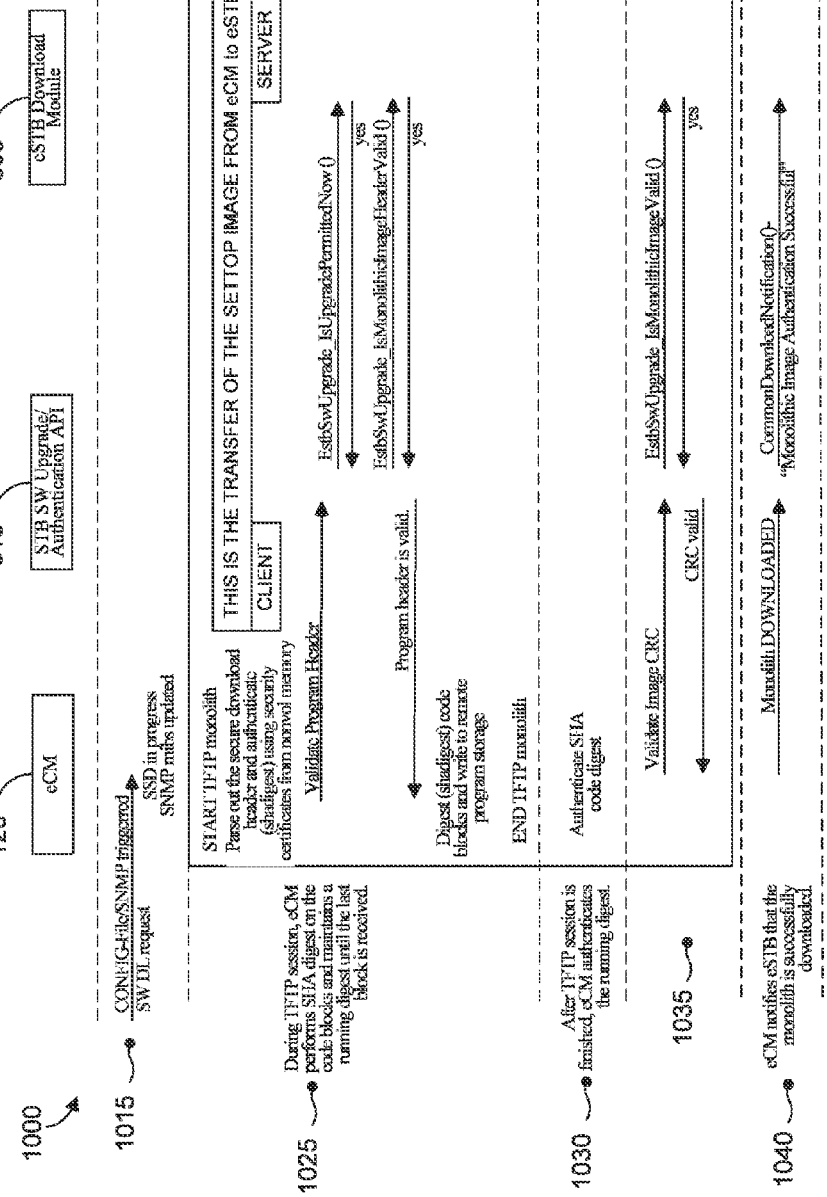

1000
120
eCM
315
STB SW Upgrade/ Authentication API
305
eSTB Download Module
1015
CONFIG file/SNMP triggered SW DL request
SSD in progress SNMP mibs updated
START TFTP monolith
Parse out the secure download header and authenticate (sha1digest) using securely certificates from nonvol memory
THIS IS THE TRANSFER OF THE SETTOP IMAGE FROM eCM to eSTB.
1020
CLIENT
SERVER
Validate Program Header
EstbSwUpgrade_IsUpgradePermittedNow ()
yes
EstbSwUpgrade_IsMonolithicImageHeaderValid ()
yes
Prior to processing an upgrade or authentication request, eCM asks eSTB whether a SW Upgrade is permitted.
eCM asks eSTB to validate the program header of monolith.
1025
During TFTP session, eCM performs SHA digest on the code blocks and maintains a running digest until the last block is received.
Program header is valid.
Digest (sha1digest) code blocks and write to remote program storage
END TFTP monolith
1030
After TFTP session is finished, eCM authenticates the running digest.
Authenticate SHA code digest
Validate Image CRC
EstbSwUpgrade_IsMonolithicImageValid ()
yes
CRC valid
After authenticating the Monolith, eCM asks eSTB to validate the image CRC.
1035
1040
eCM notifies eSTB that the monolith is successfully downloaded.
Monolith DOWNLOADED
CommonDownloadNotification()- "MonolithicImageAuthenticationSuccessful"
After monolith is downloaded, eSTB will verify the eCM code image. TO signed eCM CODE IMAGE VALIDATION SCENARIO
SSD finished SNMP mibs updated

FIG. 10

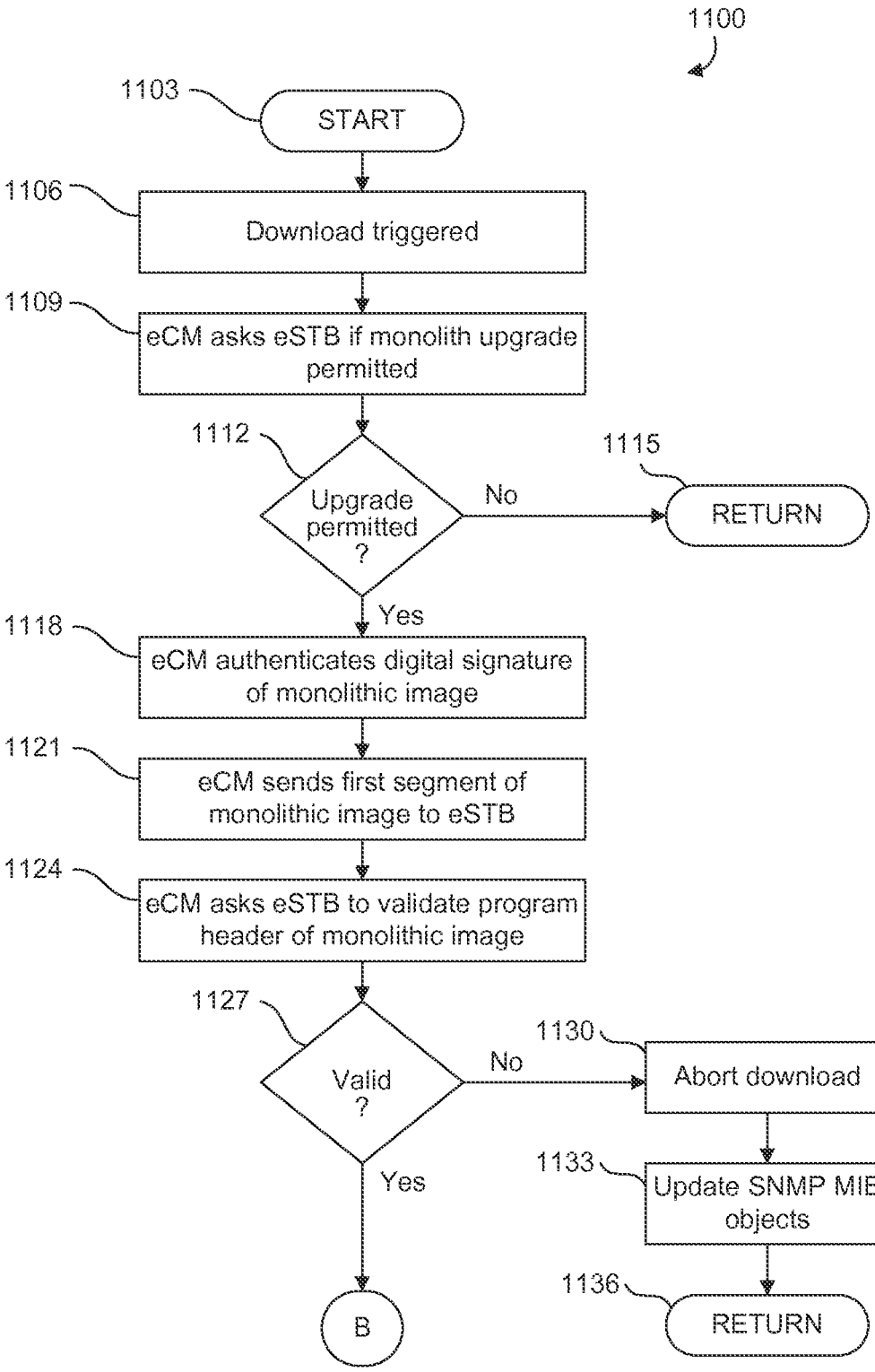

1100
1103
START
1106
Download triggered
1109
eCM asks eSTB if monolith upgrade permitted
1112
Upgrade permitted ?
No
1115
RETURN
Yes
1118
eCM authenticates digital signature of monolithic image
1121
eCM sends first segment of monolithic image to eSTB
1124
eCM asks eSTB to validate program header of monolithic image
1127
Valid ?
No
1130
Abort download
1133
Update SNMP MIB objects
1136
RETURN
Yes
B

FIG. 11A

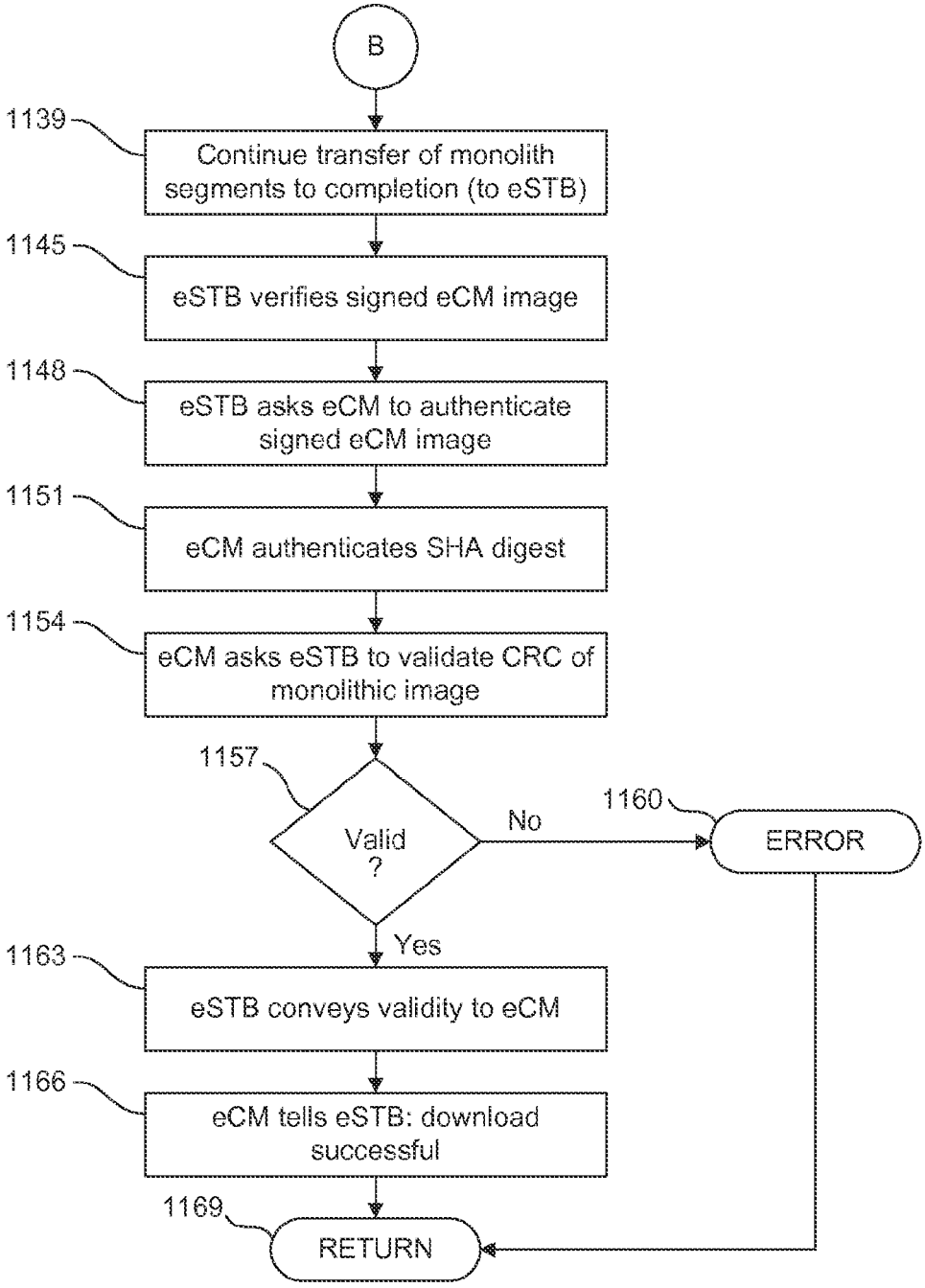

B
1139
Continue transfer of monolith segments to completion (to eSTB)
1145
eSTB verifies signed eCM image
1148
eSTB asks eCM to authenticate signed eCM image
1151
eCM authenticates SHA digest
1154
eCM asks eSTB to validate CRC of monolithic image
1157
Valid ?
No
1160
ERROR
Yes
1163
eSTB conveys validity to eCM
1166
eCM tells eSTB: download successful
1169
RETURN

FIG. 11B

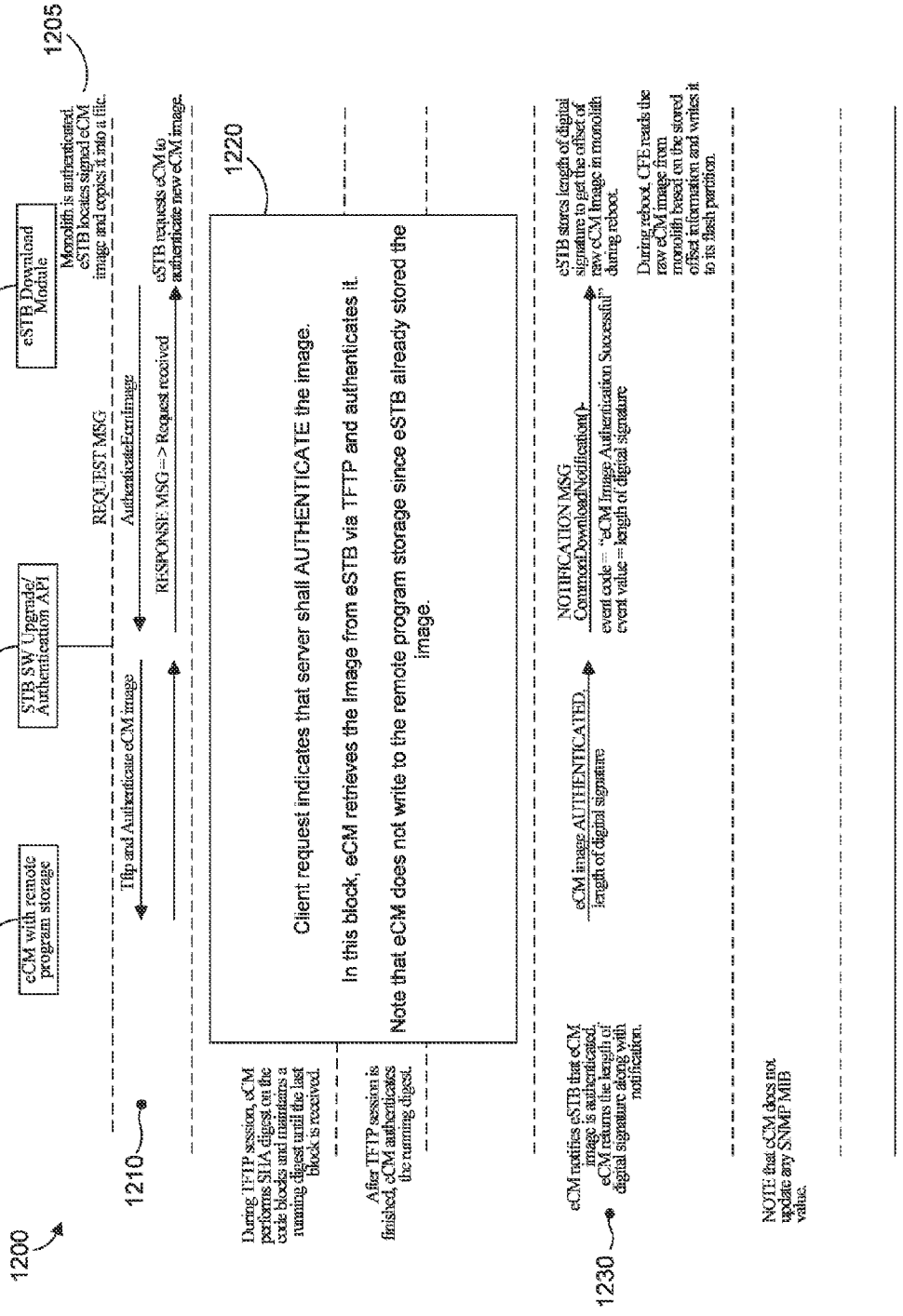

1200
120
eCM with remote program storage
315
STB SW Upgrade/ Authentication API
305
eSTB Download Module
1205
Monolith is authenticated. eSTB locates signed eCM image and copies it into a file.
REQUEST MSG
AuthenticateEcmImage
Tftp and Authenticate eCM image
RESPONSE MSG => Request received
eSTB requests eCM to authenticate new eCM image.
1210
1220
During TFTP session, eCM performs SHA digest on the code blocks and maintains a running digest until the last block is received.
After TFTP session is finished, eCM authenticates the running digest.
Client request indicates that server shall AUTHENTICATE the image.
In this block, eCM retrieves the image from eSTB via TFTP and authenticates it.
Note that eCM does not write to the remote program storage since eSTB already stored the image.
eCM notifies eSTB that eCM image is authenticated. eCM returns the length of digital signature along with notification.
1230
eCM image AUTHENTICATED. length of digital signature
NOTIFICATION MSG CommonDownloadNotification()
event code = "eCM Image Authentication Successful"
event value = length of digital signature
eSTB stores length of digital signature to get the offset of new eCM Image in monolith during reboot.
During reboot, CFE reads the new eCM image from monolith based on the stored offset information and writes it to its flash partition.
NOTE that eCM does not update any SNMP MIB value.

FIG. 12

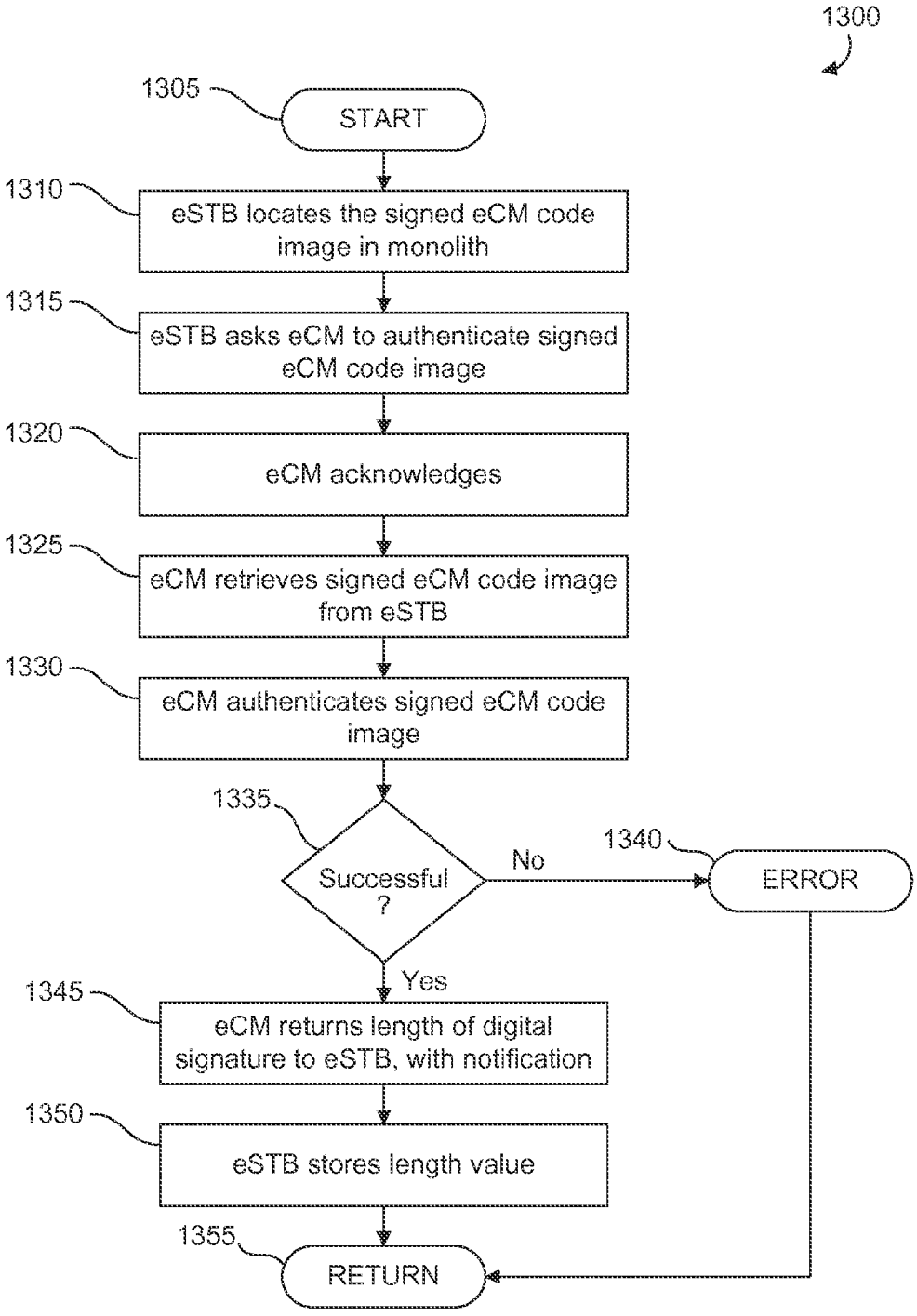

1300
1305
START
1310
eSTB locates the signed eCM code image in monolith
1315
eSTB asks eCM to authenticate signed eCM code image
1320
eCM acknowledges
1325
eCM retrieves signed eCM code image from eSTB
1330
eCM authenticates signed eCM code image
1335
Successful ?
No
1340
ERROR
Yes
1345
eCM returns length of digital signature to eSTB, with notification
1350
eSTB stores length value
1355
RETURN

FIG. 13

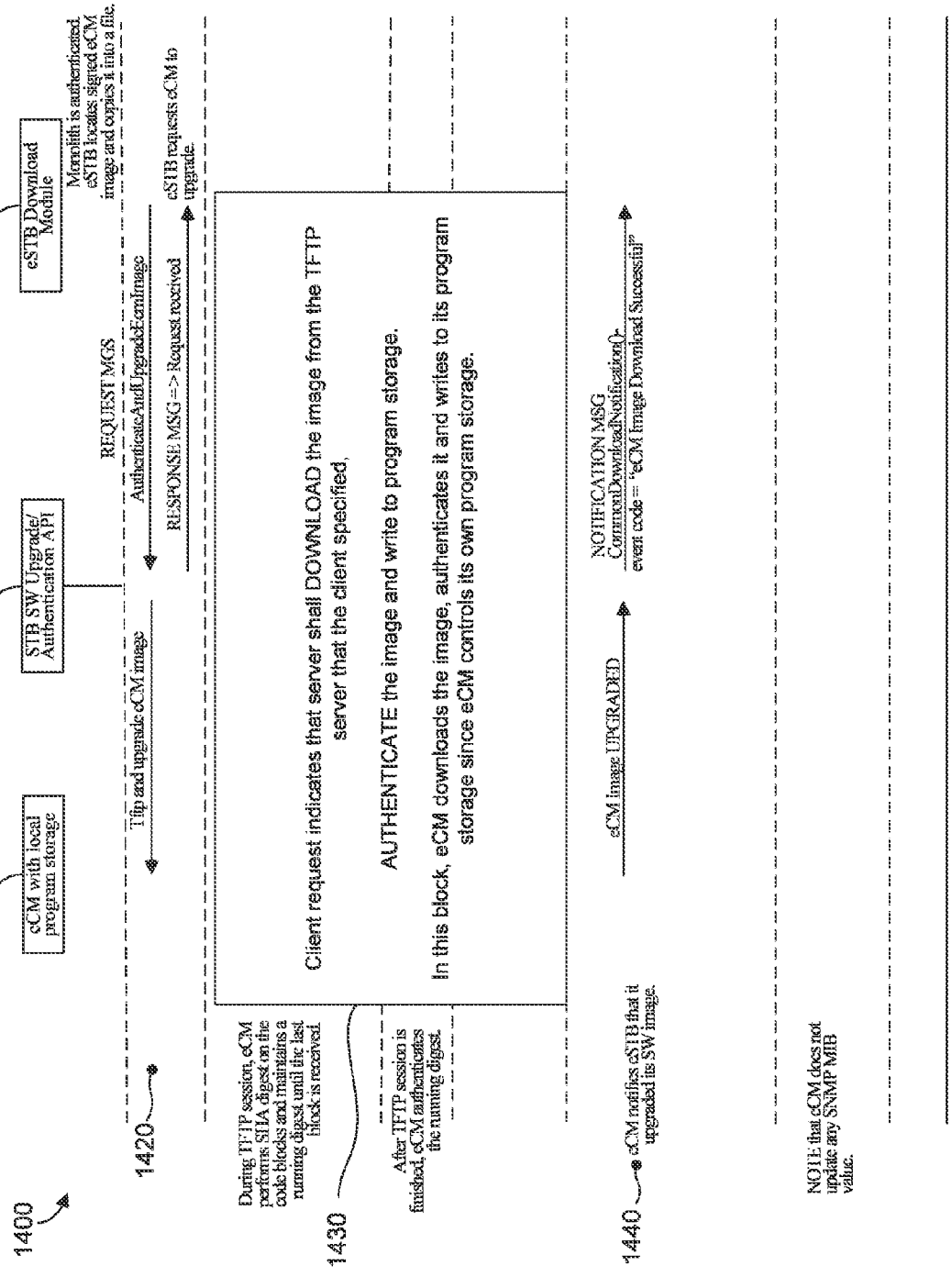

1400
120
eCM with local program storage
315
STB SW Upgrade/ Authentication API
305
eSTB Download Module
REQUEST MGS
AuthenticateAndUpgradeEcmImage
Monolith is authenticated, eSTB locates signed eCM image and copies it into a file.
1420
Tftp and upgrade eCM image
RESPONSE MSG => Request received
eSTB requests eCM to upgrade.
During TFTP session, eCM performs SHA digest on the code blocks and maintains a running digest until the last block is received.
Client request indicates that server shall DOWNLOAD the image from the TFTP server that the client specified,
AUTHENTICATE the image and write to program storage.
In this block, eCM downloads the image, authenticates it and writes to its program storage since eCM controls its own program storage.
1430
After TFTP session is finished, eCM authenticates the running digest.
eCM image UPGRADED
NOTIFICATION MSG
CommonDownloadNotification().
event code = "eCM image Download Successful"
1440
eCM notifies eSTB that it upgraded its SW image.
NOTE that eCM does not update any SNMP MIB value.

FIG. 14

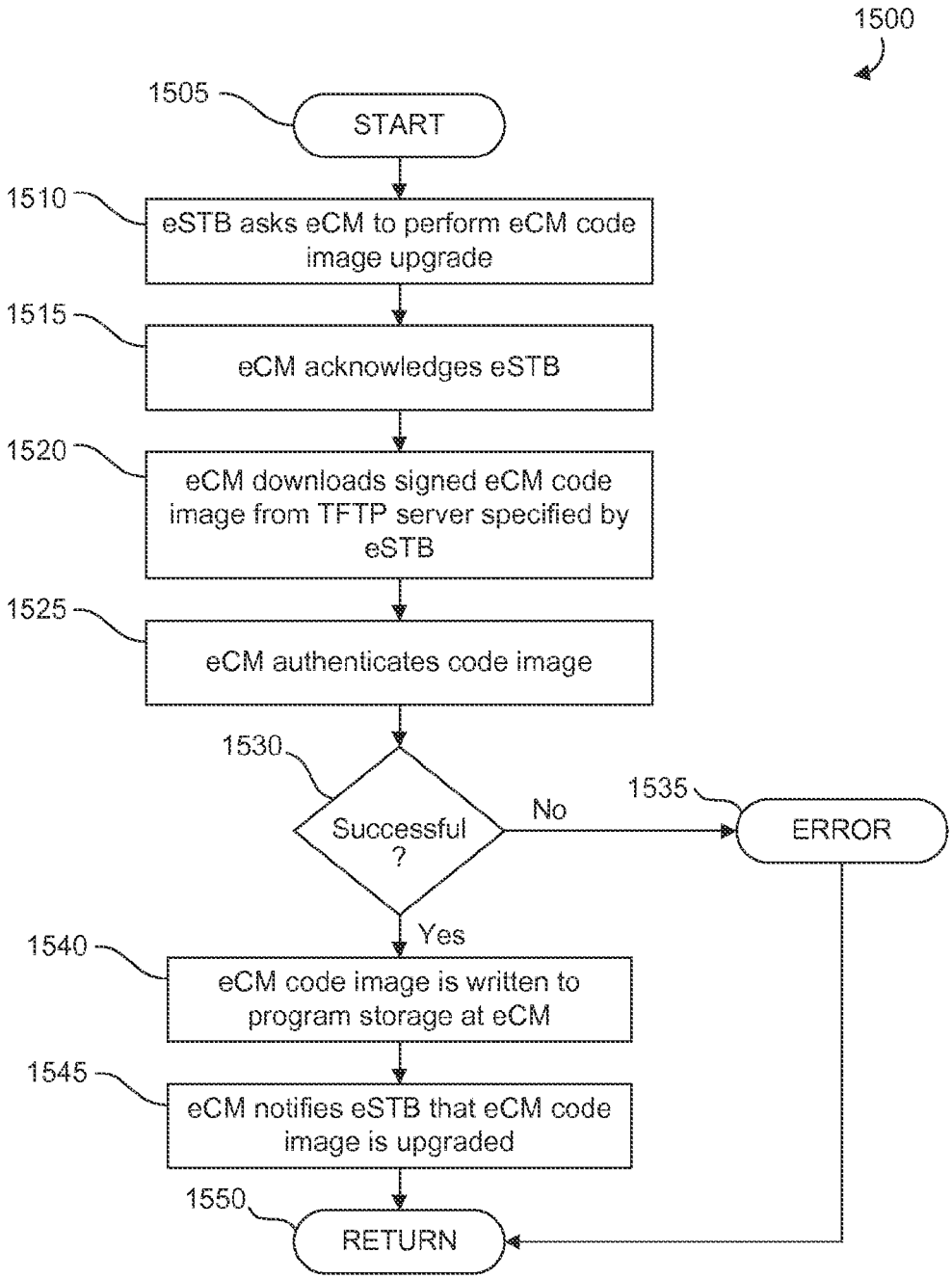

1500
1505
START
1510
eSTB asks eCM to perform eCM code image upgrade
1515
eCM acknowledges eSTB
1520
eCM downloads signed eCM code image from TFTP server specified by eSTB
1525
eCM authenticates code image
1530
Successful ?
No
1535
ERROR
Yes
1540
eCM code image is written to program storage at eCM
1545
eCM notifies eSTB that eCM code image is upgraded
1550
RETURN

FIG. 15

REQUEST MESSAGE	eSTB --> eCM	
	File Type	These 8 bits are laid out as follows: bit number (7=MSB 0=LSB) 7 4 3 0 Type | sections 4 LSBs of *'File Type'* indicate the sections of the file to be processed. 0x1 – Digital Signature 0x2 – Content 4 MSBs of *'File Type'* indicate the type. 0x1 - Monolith 0x2 - eCM 0x3 - CVT
	Flags	These 8 bits are laid out as follows: bit number (7=MSB 0=LSB) 7 4 3 0 TFTP Flag | Request Type 4 LSBs of *'Flags'* indicate the request. 0x1 - Authenticate 0x2 - Upgrade 4 MSBs of *'Flags'* indicate whether a TFTP Server Address is included or not. 0x0 – TFTP Srv. Addr. not included 0x1 – TFTP Srv. Addr. included
	If (TFTP Server Address Included Flag == '1'){	
	TFTP Server Address	IP Address of the TFTP Server from which the file to be processed will be retrieved.
	}	
	File Path Or Buffer Length	This 32-bit field contains the length of the attached buffer.
	File Path Or Buffer	If a TFTP server address is included then this buffer contains the path to the image file to be processed, otherwise this buffer contains the file to be processed (e.g. digital signature).

FIG. 16

RESPONSE MESSAGE	eCM --> eSTB	
	Return Code	This 32-bit field indicates whether the request was successfully received/processed by the server or not. Note that depending on the type of the request the server may process the request immediately and send the result of the process in the response message or the server may respond to ack the retrieval of the request and notify the client of the result of the process asynchronously.
	Return Value	Depending on the request type, this 32-bit field may contain a value like the length of the digital signature.

FIG. 17

NOTIFICATION MESSAGE	eCM --> eSTB	
	Return Code	This 32-bit field contains the result of a client request that had to be asynchronously processed by the server (e.g., eCM's firmware upgrade).

FIG. 18

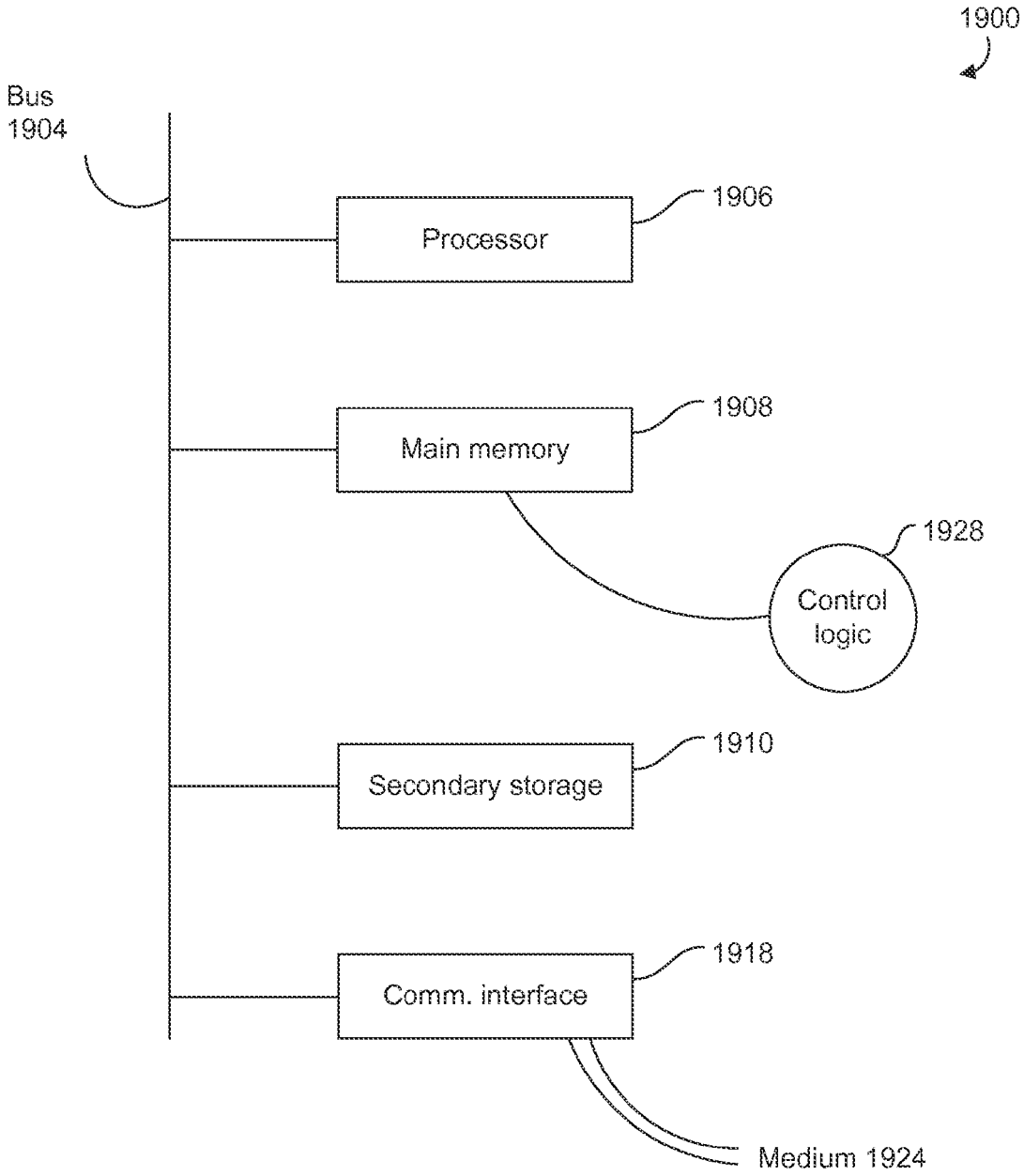

1900
Bus
1904
Processor
1906
Main memory
1908
1928
Control
logic
Secondary storage
1910
Comm. interface
1918
Medium 1924

FIG. 19

SYSTEM AND METHOD FOR UPGRADING A MULTIPROCESSOR SET-TOP BOX DEVICE WITH A MONOLITHIC FIRMWARE IMAGE

CROSS-REFERENCE TO RELATED APPLICATIONS/INCORPORATION BY REFERENCE

This is a continuation of U.S. patent application Ser. No. 12/273,476, filed Nov. 18, 2008, the disclosure of which is incorporated herewith in its entirety. In addition, the parent application Ser. No. 12/273,476 claims the benefit of U.S. Provisional Application No. 61/006,055, filed on Dec. 17, 2007, and U.S. Provisional Application No. 61/006,054, filed on Dec. 17, 2007, both of which are incorporated herein by reference in their entireties.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention described herein relates to the download of code images.

2. Background Art

In a set-top gateway host, several components may be present through which software upgrades can be received as downloads. For example, a Data Over Cable Service Interface Specification (DOCSIS) Set-top Gateway (DSG) host device that complies with OpenCable Host Device 2.0 Core Functional Requirements (OCHD2) includes an embedded DOCSIS cable modem (eCM) and an embedded set-top box (eSTB). Depending on the connection between the host and the server providing the download, some downloads may be received through the eCM only. An example of this is trivial file transfer protocol (TFTP) code downloads. Such downloads can only be done by cable modems. Other downloads may take place at the eSTB, such as a carousel download of a set-top image through a non-DOCSIS channel.

In either case, the eCM and the eSTB may need to communicate with each other. There may be security processing requirements, for example, wherein the eCM is required to perform validation and/or authentication operations on downloaded code and related data that otherwise is stored at the eST13, In other cases, the eSTB may have to request that the eCM download a set-top image. Moreover, design constraints may dictate that some functionality and resources reside at one or the other, but not both. Again, this would require that the eCM and eSTB cooperate to process downloads securely.

Hence there is a need for a system and method by which the eCM and eSTB in a set-top host device communicate efficiently in order to securely and cooperatively process downloads of code images.

BRIEF DESCRIPTION OF THE DRAWINGS/FIGURES

FIG. **1** is a block diagram illustrating the context of an embodiment of the invention.

FIG. **2** is a block diagram generally illustrating the processing of an embodiment of the invention.

FIG. **3** illustrates processing related to a code version table (CVT)-triggered carousel download, according to an embodiment of the invention.

FIG. **4** is a flowchart illustrating the processing of FIG. **3**, according to an embodiment of the invention.

FIG. **5** illustrates processing related to a CVT-triggered download over a DOCSIS channel using TFTP, according to an embodiment of the invention.

FIG. **6** is a flowchart illustrating the processing of FIG. **5**, according to an embodiment of the invention.

FIG. **7** illustrates the interaction between an eCM and an eSTB during the secure download of FIG. **5**, according to an embodiment of the invention.

FIGS. **8**A-**8**C illustrate the processing of FIG. **7** in the form of a flowchart **800**. The process begins at step **803** of FIG. **8**A.

FIG. **9** illustrates processing related to a CVT-triggered download over a DOCSIS channel using TFTP, according to an embodiment of the invention.

FIG. **10** illustrates the interaction between an eCM and an eSTB during the secure download of FIG. **9**, according to an embodiment of the invention.

FIGS. **11**A-**11**B are illustrated as flowcharts of the processing of FIG. **10**.

FIG. **12** illustrates the validation of a signed eCM code image, according to an embodiment of the invention.

FIG. **13** is a flowchart illustrating the processing of FIG. **12**, according to an embodiment of the invention.

FIG. **14** illustrates processing related to the download process where the eCM has local flash memory, enabling it to store the downloaded monolithic code image locally, according to an embodiment of the invention.

FIG. **15** is a flowchart illustrating the processing of FIG. **14**, according to an embodiment of the invention.

FIG. **16** illustrates the format of a request message, according to an embodiment of the invention.

FIG. **17** illustrates the format of a response message, according to an embodiment of the invention.

FIG. **18** illustrates the format of a notification message, according to an embodiment of the invention.

FIG. **19** is a block diagram illustrating the computing context of an embodiment of the invention.

Further embodiments, features, and advantages of the present invention, as well as the operation of the various embodiments of the present invention, are described below with reference to the accompanying drawings.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates generally to a method and system for the download and verification of code images in a multi-processor set-top device, wherein the eCM and eSTB communicate (i.e., cooperate) in order to process the download securely. The invention also provides for the secure upgrade of the Software of an embedded cable modem that runs on a processor other than the host processor.

A preferred embodiment of the present invention is now described with reference to the figures, where like reference numbers indicate identical or functionally similar elements. Also in the figures, the leftmost digit of each reference number corresponds to the figure in which the reference number is first used. While specific configurations and arrangements are discussed, it should be understood that this is done for illustrative purposes only. A person skilled in the relevant art will recognize that other configurations and arrangements can be used without departing from the spirit and scope of the invention. It will be apparent to a person skilled in the relevant art that this invention can also be employed in a variety of other systems and applications.

In an embodiment of the invention, a DOCSIS Set-top Gateway (DSG) Host device that complies with OpenCable Host Device 2.0 Core Functional Requirements (OCHD2) includes an embedded DOCSIS cable modem (eCM) and an

embedded set-top box (eSTB). The OpenCable Common Download specification (CDL 2.0) defines a standard secure software download (SSD) protocol for downloading new code images to such host devices. In this document, the code image that is used for the overall host device will be referred as the 'monolithic image'. The term 'non-DOCSIS channel' will be used to refer to a channel that the eSTB uses to download a monolithic image. A non-DOCSIS channel that is used for performing software upgrade can be, for example, a Forward Application Transport (FAT) channel or a DSG tunnel that is carried within a DOCSIS channel.

The download can be triggered through the eCM or through the eSTB. The monolithic image can be delivered to the host device through the eCM via the trivial file transfer protocol (TFTP). Alternatively, the monolithic image can be delivered through the eSTB using the digital storage medium command and control (DSM-CC) data carousel method.

The downloading of a code image to a host is illustrated in FIG. **1**. The host **110** includes an eCM **120** and an eSTB **130**. A code image **140** can be transferred to eCM **120** in host **110** using TFTP. In other circumstances the image **140** can be transferred to eSTB **130** in host **110**. The eCM **120** and eSTB **130** interact to process such downloads securely in a manner described in greater detail below.

When the TFTP method is used for download delivery, the eCM performs the TFTP using its own source IP address since the DOCSIS infrastructure is configured to permit TFTP code downloads to be performed only by cable modems. In a multi-processor set-top device where the eCM application runs on the cable modem chip and eSTB application runs on a video processing chip, the monolithic image is typically stored in the program storage device such as a flash memory that is controlled by the video processing chip. As the eCM is downloading the monolithic image via TFTP, it transfers each segment of the monolith to the eSTB. This is because the eCM does not typically have enough RAM to hold the monolithic image and transfer it to the eSTB after the download is finished.

This invention includes a system and method to transfer the monolithic image from the eCM's memory to the eSTB as the monolithic image is being downloaded. In an embodiment of the invention, the client-server model is used to manage this image transfer. In this model, the client runs on the eCM and the server runs on the eSTB; the client and server communicate via a proprietary socket protocol.

In an embodiment, when a code download is triggered, the eCM asks the eSTB whether a monolith software upgrade is permitted. If the eSTB allows the upgrade, the eCM first authenticates the digital signature of the monolith. The eCM then transfers the first segment of the monolith to the eSTB and requests that the eSTB validate the program header of monolith. If the eSTB cannot validate the program header, the eCM aborts the download and updates the DOCSIS simple network management protocol (SNMP) management information base (MIB) objects. This allows the set-top device to preserve processing resources by timely aborting the download of an incompatible image. This is useful since the size of a monolith can be quite large. Assuming that the header is successfully validated, the transfer of the segments of the monolithic image to the eSTB continues.

After the download is completed, the eCM asks the eSTB to validate the image, e.g., run a cyclic redundancy check (CRC), since the eCM must update DOCSIS SNMP MIB objects and correctly report the results of the download.

The monolith typically contains the eCM image, which may be signed or unsigned depending on the vendor. If it is signed, then eCM must authenticate its image. Moreover, depending on the layout, eCM may be set to boot from its own program storage device such as a flash device. In this case, eCM would have to upgrade its software with the new eCM image extracted from the monolith.

The system and method described herein provide for handling the software upgrade of a multi-processor set-top device whether the cable modem chip may control its own flash device or not.

The processing of an embodiment of the invention is illustrated in greater detail in FIG. **2**. A headend **210**, is shown transferring a code image to a host. In particular, the image is downloaded to either of eCM **120** or eSTB **230**. The download to eCM **120** is a trivial file transfer protocol (TFTP) download performed through a DOCSIS channel **225**. The download to eSTB **230** is a DSM-CC (Digital Storage Medium—Command and Control) data carousel download where the carousel is carried in a DSG Tunnel or Forward Application Transport (FAT) channel **235**. Hence the download can be sent to either of two different processors. If the download is sent to eSTB **230**, the security requirements of a secure download are satisfied using the information and resources of eCM **120**, such as the security certificates that may be stored in non-volatile storage in eCM **120**. This utilization of the security-related resources and information of eCM **120** is accomplished through interaction **240**, which will be described in greater detail below.

FIG. **3** shows a portion of interaction **240**, according to an embodiment of the invention. In particular, this figure shows a process **300**. This represents the communication between a download module **305** of eSTB **130** and an eCM **120** during authentication of a code version table (CVT), where the authentication process conforms to the SHA-1 authentication standard. Note that in the illustrated embodiment, this communication takes place via a software upgrade/authentication application program interface (API) **315**.

In step **317**, the eSTB download module **305** receives a signed CVT from the headend **210**. In step **320**, the eSTB requests that the eCM **120** authenticate the signed CVT. This request is in the form of a command "AuthenticateCvtFile" sent to API **315**. The authentication command is received at eCM **120** through API **315**. In step **325**, the header of the secure download header is parsed and authentication by eCM **120** begins, using the security certificates stored in non-volatile memory of eCM **120**. An SHA digest process is then performed on the CVT buffer contents. In step **330**, eCM **120** authenticates the SHA code digest. In step **340**, eCM **120** returns the length of the digital signature. The eSTB then uses this length to find the starting point of the CVT file.

Note that in the illustrated embodiment, the eCM does not update any SNMP MIB objects in the process **300**.

The processing of FIG. **3** is illustrated as a flowchart in FIG. **4**. The process begins at step **405**. At step **410**, the eSTB receives the signed CVT. In step **415**, the eSTB requests that the eCM authenticate the signed CVT. In step **420**, the eCM parses the secure download header associated with the signed CVT. In step **425**, the eCM starts authentication. In an embodiment of the invention, this authentication process uses one or more security certificates at the eCM. In step **430**, the eCM performs the authentication process, e.g., a SHA digest operation, on the contents of the buffer that holds the CVT. In step **435**, the eCM authenticates the code digest that results from the authentication process. In step **440**, the eCM returns, to the eSTB, the length of the digital signature from the signed CVT. In step **445**, the eSTB uses this length to find the start of the CVT file in the signed. CVT. The process concludes at step **450**.

FIG. **5** further illustrates interaction **240** according to an embodiment of the invention. This figure shows a process **500**, the processing of a code verification certificate (CVC). In step **510**, the eSTB receives a CVC. In step **520**, the eSTB requests that the eCM **120** process the CVC buffer. Again, this request is made by the eSTB in the form of a command to API **315**. In the illustrated embodiment, this command is called "CommonDownloadProcessCVC." In step **530**, the eCM **120** decodes and validates the CVC settings, and stores the CVC settings if the validation is successful. In step **540**, the eCM **120** returns the length of the CVC to the eSTB. The eSTB then uses the CVC length to find the offset of the next CVC of the CVT.

Again, note that in the illustrated embodiment, the eCM does not update any SNMP MIB objects in process **500**.

The processing of FIG. **5** is illustrated as a flowchart in FIG. **6**. The process begins at step **605**. In step **610**, the eSTB receives the CVC. In step **615**, the eSTB asks the eCM to process the contents of the buffer containing the CVC. In step **620**, the eCM decodes and attempts validation of the CVC settings. In step **625**, a determination is made as to whether the CVC settings are valid. If not, an error condition is noted in step **630** and the process concludes at step **650**. If the settings are valid, the process continues at step **635**, where the eCM stores the CVC settings. In step **640**, eCM returns the length of the CVC to the eSTB. In step **645**, the eSTB uses this length to find the offset of the next CVC in the CVT.

FIG. **7** further illustrates interaction **240** according to an embodiment of the invention. This figure shows a process **700**, the processing of a CVT-triggered carousel download. In step **710**, the eSTB receives a CVT-triggered software download request. In the illustrated embodiment, this request is a DSM-CC data carousel download request. In step **715**, the eSTB asks the eCM **120** to validate the code image's digital signature. This request is sent in the form of a command to the API **315**. In step **720**, eCM **120** parses the secure download header and authenticates it, using one or more security certificates stored in non-volatile memory of eCM **120**. In step **725**, the eSTB-triggered secure download is now active, and SNMP MIB objects are updated. In step **730**, the eCM **120** returns the length of the digital signature to the eSTB, which uses this value to strip off the digital signature and start downloading a monolithic code image. In step **735**, the code image is downloaded to the eSTB.

In step **740**, the eSTB asks eCM **120** to authenticate the monolithic code image. Again, this request takes the form of a command to the API **315**. In step **745**, eCM **120** asks the eSTB whether a software upgrade is permitted. If so, the process continues. The eCM **120** then asks the eSTB to validate the program header of the monolithic image. If the header is valid, the eCM **120** is so informed. The TFTP session starts, during which the eCM **120** performs the SHA digest process on the received code blocks. A running digest is maintained until the last block is received. The TFTP session then concludes.

In step **750**, the eCM **120** authenticates the running digest. In step **755**, after the code image has been authenticated, eCM **120** asks the eSTB to validate the image cyclic redundancy code (CRC). This request is conveyed to the eSTB via the API **315**. If the CRC is successfully validated, an indication to that effect is communicated back to eCM **120**. The eCM **120** then tells the eSTB that the monolithic code image has been authenticated in step **760**. SNMP MIB objects are then updated as appropriate.

Note that while the above processes are described in terms of SHA-1 authentication, the concepts of the invention can be implemented using other forms of authentication as well.

FIGS. **8**A-**8**C illustrate the processing of FIG. **7** in the form of a flowchart **800**. The process begins at step **803** of FIG. **8**A. In step **806**, the eSTB receives the CVT-triggered download request. In step **809**, the eSTB downloads the first block of the monolithic image. In step **812**, the eSTB asks the eCM to validate the digital signature of this image. In step **815**, the eCM parses the secure download header in the first block of the image. The header is authenticated using the security certificates held at the eCM, in an embodiment of the invention. In step **818**, the eCM returns the length of the digital signature to the eSTB. In step **821**, the eSTB uses this length to remove the digital signature from the monolithic image.

In step **824**, the eSTB continues to download the monolithic image. In step **827**, the eSTB asks the eCM to authenticate the monolithic image. In step **830**, the eCM asks the eSTB whether a software upgrade is permitted. Continuing to FIG. **8**B, a determination is made in step **833** as to whether such an upgrade is permitted. If not, the process ends at step **836**. If an upgrade is permitted, the process continues at step **839**. Here, the eCM asks the eSTB to validate the program header of the monolith. If the header is not valid as determined in step **842**, an error condition is noted in step **845**. If the header is valid, the process continues at step **848**, where the eCM is informed of the validity of the image header.

In step **851**, the TFTP session starts. In step **854**, the eCM maintains a running SHA digest during the session. In step **857**, the TFTP session ends. In step **860**, the eCM attempts to authenticate the running digest. Continuing to FIG. **8**C, a determination is made in step **863** as to whether the authentication was successful. If so, then in step **869** the eCM asks the eSTB to validate the error detection code of the image. In the illustrated embodiment, this code is a cyclic redundancy code (CRC). In step **872**, a determination is made as to whether the CRC is valid. If not, an error condition is raised in step **866**. If the CRC is valid, the process continues at step **875**, where the successful validation of the CRC is communicated to the eCM. In step **878**, the eCM informs the eSTB that the image has been authenticated. In step **881**, the SNMP MIB objects are updated. The process concludes at step **884**.

A CVT-triggered download can take place over a DOCSIS channel using TFTP. This is shown in FIG. **9**, according to an embodiment of the invention. In step **910**, eSTB download module **305** receives the download request and sends the request to eCM **120**. This takes the form of a REQUEST message that is sent via API **315**, asking that the eCM **120** authenticate and upgrade the monolithic image. In step **920**, this request (effectively a client request) indicates that the eCM **120** (acting as a server) is to download the monolithic image via the DOCSIS channel, authenticate the monolithic image, and transfer the monolithic image to eSTB download module **305**. The eCM **120** does so, writing the monolithic image to remote program storage at eSTB download module **305**. In step **930**, eCM **120** notifies eSTB download module **305** that the monolithic image has been successfully downloaded. This is received via API **315** as an appropriate NOTIFICATION message.

FIG. **10** illustrates the interactions that take place between eCM **120** and eSTB download module **305** during the secure download of the monolithic image in the previous example, according to an embodiment of the invention. The interactions between eCM **120** and eSTB download module **305** contained in box **1020** of FIG. **10** include the transfer of the monolithic image from eCM **120** to eSTB download module **305**.

The download to the host was triggered by a configuration file or via SNMP as shown in step **1015**. In step **1025**, the TFTP transfer of the monolithic image begins. Here, eCM

120 assumes the role of a client with respect to eSTB 130, while the eSTB assumes the role of a server. eCM 120 parses out the secure download header, eCM 120 asks eSTB download module 305 to validate the program header. This request is made via API 315 in this embodiment. The eSTB download module 305 then determines whether a software upgrade is permitted. If so, eSTB download module 305 proceeds to attempt validation of the header of the monolithic image. If the validation succeeds, this is conveyed to eCM 120, and the transfer of the monolithic image to eSTB download module 305 proceeds.

During the TFTP session, eCM 120 performs an SHA digest operation on the received code blocks and maintains a running digest until the last block is received. The code blocks undergo the digest process, then are written to remote program storage.

In step 1030, after the TFTP session is over, eCM 120 authenticates the running digest. In step 1035, eCM 120 asks eSTB download module 305 to validate the CRC of the monolithic image. Again, this request proceeds via API 315. If validation is successful, eCM 120 is so informed. In step 1040, eCM 120 notifies eSTB download module 305 that the monolithic image has been successfully downloaded. SNMP MIB objects are then updated as necessary.

The processing of FIG. 10 is illustrated as flowcharts in FIGS. 11A-11B. The process begins at step 1103. In step 1106, the download is triggered. In step 1109, the eCM asks the eSTB if an upgrade of the software is permitted. If, in step 1112, an upgrade is not permitted, then the process concludes at step 1115. If the upgrade is permitted, then the process continues at step 1118. Here, the eCM authenticates the digital signature of the monolithic image. In step 1121, the eCM sends the first segment of the monolithic image to the eSTB.

In step 1124, the eCM asks the eSTB to validate the program header of the monolithic image. In step 1127, validity of the program header is determined. If the header is not valid, then in step 1130, the download is aborted. The SNMP MIB objects are then updated in step 1133, and the process concludes at step 1136. If the program header is found to be valid in step 1127, then the process continues at step 1139 in FIG. 11B. At step 1139 the transfer of segments of the monolithic image to the eSTB is continued to completion.

In step 1148, the eSTB asks the eCM to authenticate the signed eCM image. In step 1151, the eCM authenticates the SHA digest. In step 1154, the eCM asks the eSTB to validate the CRC of the monolithic image. If the image is found to be valid in step 1157, then in step 1163, the eSTB communicates the validity to the eCM. In step 1166, the eCM tells the eSTB that the download was successful. If it is determined in step 1157 that the monolithic image is not valid, then an error condition is raised in step 1160.

The eSTB will then verify the signed eCM code image. Thus process is illustrated in FIG. 12, according to an embodiment of the invention. In step 1205, eSTB download module 305 locates the signed eCM code image in the monolithic image. In step 1210, eSTB download module 305 asks that eCM 120 authenticate the signed eCM code image. This takes the form of a REQUEST message sent via API 315. This message is acknowledged with a RESPONSE message that is received at eSTB download module 305. In step 1220, the REQUEST message indicates to eCM 120 (acting as a server) that the signed eCM image is to be authenticated. The eCM 120 retrieves the signed eCM image from eSTB download module 305 using TFTP and authenticates it. Since the REQUEST message indicates that the image is to be authenticated only and not be upgraded, eCM 120 does not write to the remote program storage at the eSTB.

In step 1230, eCM 120 notifies eSTB download module 305 that the signed eCM image is authenticated and returns the length of the digital signature to eSTB download module 305. This is received at eSTB download module 305 as a NOTIFICATION message. In an embodiment of the invention, the eSTB then stores this length and uses it to get the offset of the raw eCM image in the monolith during subsequent reboot.

FIG. 13 illustrates the processing of FIG. 12 as a flowchart. The process begins at step 1305. In step 1310, the eSTB locates the signed eCM code image in the monolith. In step 1315, the eSTB asks the eCM to authenticate the signed eCM code image. The eCM acknowledges the request in step 1320. In step 1325, the eCM retrieves the signed eCM code image from the eSTB. In step 1330, the eCM authenticates the signed eCM code image. If the authentication is found not to be successful in step 1335, then an error condition is raised in step 1340. If the authentication is successful, then the process continues in step 1345. Here, the eCM returns the length of the digital signature to the eSTB, along with notification of the success of the authentication. In step 1350, the eSTB stores the length. The process concludes at step 1355.

The eCM 120 may have local flash memory, enabling it to store an eCM image locally. This is illustrated in FIG. 14, according to an embodiment of the invention. In step 1420, eSTB download module 305 requests that eCM 120 perform an image upgrade. This takes the form of a REQUEST message, sent via API 315. eCM 120 sends an acknowledgement, which is received by eSTB download module 305 in the form of a RESPONSE message. In step 1430, eCM 120 (acting as a server) downloads the signed eCM image from a TFTP server specified by the eSTB (acting as a client). eCM 120 downloads the image and authenticates it. The image is then written to program storage of eCM 120. This storage may be in the form of flash memory local to eCM 120 in an embodiment of the invention. In step 1440, eCM 120 informs eSTB download module 305 that the image of eCM 120 has been upgraded. This is received by the eSTB as a NOTIFICATION message.

The processing of FIG. 14 is illustrated as a flowchart in FIG. 15. The process begins at step 1505. In step 1510, the eSTB asks the eCM to perform the eCM code image upgrade. This is acknowledged by the eCM in step 1515. In step 1520, the eCM downloads the signed eCM code image from the TFTP server specified by the eSTB. The eCM performs the authentication process in step 1525. If this authentication is successful, the process continues at step 1540. Here, the eCM code image is written to program storage at the eCM, such as a flash memory. In step 1545, the eCM notifies the eSTB that the eCM code image has been upgraded. If the authentication is not successful (as determined in step 1530), then an error condition is raised in step 1535. The process concludes at step 1550.

The structure of REQUEST, RESPONSE, AND NOTIFICATION messages between eCM 120 and eSTB 130 is shown in FIGS. 16-18 respectively, according to an embodiment of the invention.

Note that while the above processes are described in terms of SHA-1 authentication, this is not meant to limit the scope of the invention; the concepts of the invention can also be implemented using other forms of authentication.

Moreover, the invention described above can be implemented using hardware, firmware, or software, or any combination thereof. Both hardwired logic and/or programmable logic may be used. In an embodiment of the invention, the eCM and eSTB may be microprocessor based, wherein the

microprocessor(s) execute processing instructions that effect the messaging and operations discussed herein.

By leveraging the existing functionalities in the eCM and eSTB, this method avoids having all software upgrade functionality in both the eCM and eSTB. If the cable modem is running in standalone cable modem mode a software upgrade trigger will only upgrade cable modem software. If the cable modem is running in embedded cable modem mode, a software upgrade trigger will upgrade set-top device software. Furthermore, this system provides methods to upgrade the software of an eCM that is running in embedded cable modem mode since a software upgrade trigger sent in a DOCSIS channel will not upgrade eCM software alone.

Computing Context

In an embodiment of the present invention, the system and operation of the present invention described herein are implemented using a programmable processor at each of the eCM and eSTB. Such a processor is shown in FIG. **19**. The processor **1906** is connected to a communication bus **1904**. The processor **1906** may operate in conjunction with a main or primary memory **1908**, such as random access memory (RAM). The primary memory **1908** has stored therein control logic **1928** (computer software), and data. Control logic **1928** may include the images discussed above

The processor **1906** may also interoperate with one or more secondary storage devices **1910**. The secondary storage device **1910** may comprise, for example, a removable storage device or other read/writable memory device. Device **1910** may include a computer useable or readable storage medium having stored therein (or capable of storing therein) computer control logic **1928** and/or data.

The processor **1906** further operates with a communication or network interface **1918**. The interface **1918** enables the processor **1906** to communicate with remote devices. For example, the interface **1918** allows the processor **1906** to communicate over communication network or medium **1924** (representing a form of a computer useable or readable medium), such as LANs, WANs, the Internet, etc. The interface **1918** may interface with remote sites or networks via wired or wireless connections.

In particular, control logic **1928** may be transmitted to and main memory **1908** via the communication medium **1924**. More particularly, the illustrated system may receive and transmit carrier waves (electromagnetic or optical signals) modulated with control logic **1928** via the communication medium **1924**. In particular, in the context of an eCM, medium **1924** can serve to convey the messages and images (or portions thereof) to and from the eSTB and/or a headend server. Analogously, in the context of an eSTB, medium **1924** can serve to convey the messages and images (or portions thereof) to and from the eCM and/or a headend server.

Any apparatus or manufacture comprising a computer useable or readable medium having control logic (software) stored therein is referred to herein as a computer program product or program storage device. This includes, but is not limited to, the main memory **1908** and the secondary storage **1910**. Such computer program products, having control logic stored therein that, when executed by one or more data processing devices, cause such data processing devices to operate as described herein, represent embodiments of the invention. Control logic **1928** may also be sent to system **1900** using carrier waves modulated with the control logic.

The invention can work with software, hardware, and/or operating system implementations other than those described herein. Any software, hardware, and operating system implementations suitable for performing the functions described herein can be used.

CONCLUSION

It is to be appreciated that the Detailed Description section, and not the Abstract section, is intended to be used to interpret the claims. The Abstract section may set forth one or more but not all exemplary embodiments of the present invention as contemplated by the inventor, and thus, are not intended to limit the present invention and the appended claims in any way.

The present invention has been described above with the aid of functional building blocks illustrating the implementation of specified functions and relationships thereof, The boundaries of these functional building blocks have been arbitrarily defined herein for the convenience of the description. Alternate boundaries can be defined so long as the specified functions and relationships thereof are appropriately performed.

The foregoing description of the specific embodiments will so fully reveal the general nature of the invention that others can, by applying knowledge within the skill of the art, readily modify and/or adapt for various applications such specific embodiments, without undue experimentation, without departing from the general concept of the present invention. Therefore, such adaptations and modifications are intended to be within the meaning and range of equivalents of the disclosed embodiments, based on the teaching and guidance presented herein. It is to be understood that the phraseology or terminology herein is for the purpose of description and not of limitation, such that the terminology or phraseology of the present specification is to be interpreted by the skilled artisan in light of the teachings and, guidance.

The breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the claims and their equivalents.

What is claimed is:

1. A method, comprising:

requesting, at a first device, that a second device determine whether a software upgrade comprising a monolithic code image is permitted;

authenticating a digital signature of the monolithic code image;

sending a first segment of the monolithic code image to the second device, wherein the first segment comprises a header of the monolithic code image;

requesting the second device to validate the header;

receiving a validation of the header from the second device;

sending the monolithic code image to the second device; and

requesting the second device to validate the monolithic code image.

2. The method of claim **1**, wherein the step of requesting the second device to validate the monolithic code image comprises sending a cyclic redundancy code (CRC) of the monolithic code image to be validated at the second device.

3. The method of claim **1**, further comprising:

locating a first device code image in the monolithic code image;

authenticating the first device code image; and

sending a length of a digital signature of the first device code image to the second device.

4. The method of claim **1**, further comprising:

receiving a request, from the second device, to authenticate a signed code version table (CVT);

authenticating the signed CVT; and

returning, to the second device, a length of a digital signature of the signed CVT to allow the second device to find the start of a CVT file in the signed CVT.

5. The method of claim 4, further comprising:
receiving a request from the second device to process a Code Verification Certificate (CVC);
validating settings of the CVC after decoding the CVC;
after validation of the settings, storing the settings of the CVC; and
sending a length of the CVC to allow the second device to locate a next CVC in the signed CVT.

6. The method according to claim 1, further comprising:
receiving a request, from the second device, to authenticate a signed code version table (CVT),
authenticating the signed CVT, and
returning, to the second device, a length of a digital signature of the signed CVT to allow the second device to find the start of a CVT file in the signed CVT before determining at the second device whether a software upgrade is permitted.

7. The method according to claim 4, further comprising:
receiving a request from the second device to process a Code Verification Certificate (CVC),
validating settings of the CVC after decoding the CVC,
after validation of the settings, storing the settings of the CVC, and
sending a length of the CVC to allow the second device to locate a next CVC in the signed CVT before determining at the second device whether the software upgrade is permitted.

8. The method according to claim 1, wherein the requesting is triggered by a configuration file or via Simple Network Management Protocol (SNMP).

9. The method according to claim 4, wherein the authenticating the signed CVT comprises:
parsing a secure download header of the signed CVT;
authenticating the secure download header using security certificates stored on the first device;
performing a Secure Hashing Algorithm (SHA) digest process on remaining contents of the signed CVT; and
authenticating a SHA digest code of the SHA digest process.

10. The method of claim 1, further comprising:
performing a running Secure Hashing Algorithm (SHA) digest process on code blocks of the monolithic code image; and
authenticating the running SHA digest process.

11. A system, comprising:
a network interface configured to communicate with a second device;
a memory; and
a processor coupled to the memory and the network interface, wherein the processor is configured to:
request the second device to determine whether a software upgrade comprising a monolithic code image is permitted,
authenticate a digital signature of the monolithic code image,
send a first segment of the monolithic code image to the second device, wherein the first segment comprises a header of the monolithic code image,
request the second device to validate the header,
receive a validation of the header from the second device,
send the monolithic code image to the second device, and
request the second device to validate the monolithic code image.

12. The system of claim 11, wherein the processor is further configured to request the second device to validate a cyclic redundancy code (CRC) of the monolithic code image.

13. The system of claim 11, wherein the processor is further configured to:
locate a device code image in the monolithic code image,
authenticate the device code image, and
send a length of a digital signature of the device code image to the second device.

14. The system of claim 11, wherein the processor is further configured to:
receive a request, from the second device, to authenticate a signed code version table (CVT),
authenticate the signed CVT, and
return, to the second device, a length of a digital signature of the signed CVT to allow the second device to find the start of a CVT file in the signed CVT.

15. The system of claim 14, wherein the processor is further configured to:
receive a request from the second device to process a Code Verification Certificate (CVC),
validate settings of the CVC after decoding the CVC,
after validating the settings, store the settings of the CVC in the memory, and
send a length of the CVC to allow the second device to locate a next CVC in the signed CVT.

16. The system of claim 11, wherein the processor is further configured to:
receive a request, from the second device, to authenticate a signed code version table (CVT),
authenticate the signed CVT, and
return, to the second device, a length of a digital signature of the signed CVT to allow the second device to find the start of a CVT file in the signed CVT before determining at the second device whether the software upgrade is permitted.

17. The system of claim 14, wherein the processor is further configured to:
receive a request from the second device to process a Code Verification Certificate (CVC),
validate settings of the CVC after decoding the CVC,
after validating the settings, store the settings of the CVC, and
send a length of the CVC to allow the second device to locate a next CVC in the signed CVT before determining at the second device whether the software upgrade is permitted.

18. The system of claim 11, wherein the requesting the second device to determine whether the software upgrade is permitted is triggered after receiving, by the receiver, a configuration file or a Simple Network Management Protocol (SNMP) message.

19. The system of claim 14, wherein the processor is further configured to:
parse a secure download header of the signed CVT;
authenticate the secure header using security certificates stored in the memory;
perform a Secure Hashing Algorithm (SHA) digest process on remaining contents of the signed CVT; and
authenticate a SHA digest code of the SHA digest process.

20. The system of claim 11, wherein the processor is further configured to:
perform a running Secure Hashing Algorithm (SHA) digest process on code blocks of the monolithic code image; and
authenticate the running SHA digest process.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 9,100,696 B2
APPLICATION NO. : 13/952126
DATED : August 4, 2015
INVENTOR(S) : Pinar Taskiran-Cyr

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

IN THE CLAIMS

Column 10, line 51, please replace "wherein the step of requesting" with --wherein requesting--.

Signed and Sealed this
Sixth Day of September, 2016

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office